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HARVARD CITY PLANNING STUDIES

VOLUME I

AIRPORTS

Their Location, Administration, and Legal Basis

BY

HENRY V. HUBBARD, MILLER McCLINTOCK,
AND FRANK B. WILLIAMS

ASSISTED BY

PAUL MAHONEY AND HOWARD K. MENHINICK

VOLUME II

BUILDING HEIGHT, BULK, AND FORM

How Zoning Can Be Used as a Protection against
Uneconomic Types of Buildings on High-cost Land

BY

GEORGE B. FORD

ASSISTED BY

A. B. RANDALL AND LEONARD COX

VOLUME III

NEIGHBORHOODS OF SMALL HOMES

Economic Density of Low-cost Housing in America and England

BY

ROBERT WHITTEN AND THOMAS ADAMS

HARVARD CITY PLANNING STUDIES

II

BUILDING HEIGHT, BULK, AND FORM

LONDON: HUMPHREY MILFORD
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Photograph by Peter A. Juley & Son

Shreve, Lamb and Harmon, Architects

THE EMPIRE STATE BUILDING, NEW YORK CITY

From drawing by Hugh Ferriss

BUILDING HEIGHT BULK, AND FORM

HOW ZONING CAN BE USED AS A
PROTECTION AGAINST UNECO-
NOMIC TYPES OF BUILDINGS
ON HIGH-COST LAND

BY

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CAMBRIDGE

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CHAIRMAN, HARVARD UNIVERSITY SCHOOL OF CITY PLANNING

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GEORGE BURDETT FORD

June 24, 1879 — August 13, 1930

Trained as an architect, at first in this country, and then at the École des Beaux Arts, George Burdett Ford was soon primarily interested in the field of City Planning. In his service with the New York Commission on City Planning and the Commission on Building Districts and Restrictions, in his large and varied professional work as a city planner, in his work for the French Government in replanning Rheims and Soissons, in his lecturing, in his writing, he had become an international leader in the City Planning movement.

As an architect and an artist, he had a profound influence on modern "skyscraper" architecture. The conception of the "Zoning Envelope" within which the form of the restricted building must lie, the first visualization of the architectural forms so brought about which now create a new architectural style, — these were primarily the work of George B. Ford during the drafting of the New York Zoning Ordinance passed in 1916.

Perhaps more than any other architect, he faced squarely and studied completely the factors of the economics of construction, upkeep, use, and mutual amenity of city buildings, as an inseparable and underlying part of the whole problem the final solution of which is the efficient and beautiful neighborhood or district rather than the individual structure.

He died, it might be said, in armor and on the field of battle. He had hardly settled to his duties as General Director of the Regional Plan Association of New York, his task being to keep the Plan a living force and an inspiration to the Region and to the country at large. On the very day before his death he had finished the writing of a report for the Harvard School of City Planning on Building Height, Bulk, and Form which carries further some of the ideas and ideals for which he had fought so well.

His whimsical humor, his amazingly constant good temper, his optimism and enthusiasm backed by the most self-sacrificing hard work, were a gift to the world which will not be replaced, — nor forgotten.

— From Editorial in *City Planning*, October, 1930.

THE HARVARD CITY PLANNING STUDIES

SERIES PREFACE

The increased recognition of civic responsibility for guiding and rationalizing urban and regional growth brought about the establishment in 1929 by Harvard University of the Graduate School of City Planning, with research as a principal function. The facts and conclusions developed in a series of special studies, each conducted by a leading expert, are being published as **THE HARVARD CITY PLANNING STUDIES**, of which from one to three volumes will appear each year. The university hopes to render substantial service to the communities of this country by thus laying before the public and those concerned in civic development — city officials, engineers, architects, landscape architects, planning consultants, realtors, builders, lawyers, members of chambers of commerce — freshly gathered and analyzed information, compressed into monographs appearing shortly after each investigation is brought to a conclusion. While research alone can never solve the complicated problems of civic growth, it can contribute constructively if the facts selected are vital and representative, and presented in a form facilitating actual application in the promotion of wholesome trends of community life.

This present volume, the second of the series, embodies the research undertaken by the late George B. Ford primarily with a view to determining the optimum size and shape of buildings on high-priced land under conditions present or reasonably to be hoped for, and to suggesting in what way zoning may be used to facilitate desirable conditions. It should thus furnish solid and specific help to those dealing in any responsible capacity especially with commercial or apartment buildings on high-priced land, as well as to legislative bodies dealing with the regulation of the bulk and lot-coverage of such buildings. It must be emphasized that this report concerns itself only with areas in which land is already high-priced land. Also in the press at this time is another volume of the **HARVARD CITY PLANNING STUDIES**, written by Mr. Robert

Whitten and Mr. Thomas Adams, entitled *NEIGHBORHOODS OF SMALL HOMES: ECONOMIC DENSITY OF LOW-COST HOUSING IN AMERICA AND ENGLAND*. In this case the investigation deals with residential land near the other end of the scale of values from the land considered by Mr. Ford.

It is the endeavor of the Harvard School of City Planning, in these two researches as in all others, not to attempt the impossible in comprehensiveness, but to render available on each subject some definite, timely, and valuable information, and, perhaps even better, to stir up others to get more, and more precise, information of which our preliminary exploration has shown the possibility, the need, and perhaps the direct financial value.

THEODORA KIMBALL HUBBARD
Editor of Research

HENRY V. HUBBARD
Chairman

HARVARD UNIVERSITY
SCHOOL OF CITY PLANNING
December 1, 1930.

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EDITOR'S NOTE

This report is the last considerable work which left the hands of George B. Ford. He had completed the entire first draft of all the material, and was just organizing with the Chairman of the School the procedure of checking, clarifying, and referencing when his sudden death brought his task to an end.

The Chairman of the School acting as Editor and literary executor of this research has carried on to the best of his ability. There have been questions of choice of emphasis, of inclusion or exclusion of material, which the Editor has had to decide. In each case he has done, so far as he knew, what Mr. Ford would have done in his place, and he believes that the report as it stands contains nothing of which Mr. Ford would not in principle approve.

This research, as we have also pointed out, elsewhere, deals primarily with one specific and restricted phase of a complicated subject: namely, the optimum size and shape of buildings on land of high value, obtainable under present conditions or under conditions probable or fairly to be hoped and striven for in the near future. Its conclusions are made concrete by being embodied in a suggested zoning ordinance, and by being illustrated by a series of building envelope graphs.

There is no part of the field of City Planning more complicated, more uncertain, or more controversial than that surrounding the subject of this report. For instance, in regard to light and air around tall buildings, we do not yet know what is the minimum amount of daylight which is enough for the complete healthfulness of a place in which to live or work. Indeed the practical question never has existed in so simple a form, and never will. Many other considerations are always involved. No physiological or psychological laboratory experiment will give us the whole answer. All that we can do now, therefore, is to apply such experience and knowledge as we have of our modern tall buildings and, using common sense more than mathematics, take as a reasonable minimum amount of daylight what appears to us in fact

to be such. Since, however, we are seeking in the tall building satisfactory living and working conditions rather than temporary profits, we should be entirely sure that we mean by a "reasonable minimum" of light the least light consistent with human health and efficiency, and not the least light that will be tolerated and paid for at a profit to the building owner. This distinction Mr. Ford has had in mind.

Again, as regards the relation of tall buildings to traffic, there are at present honest differences of opinion as to how much of the present congestion of traffic in our large cities, especially New York, is due directly to tall buildings, and how much to other causes related to tall buildings only as they are all manifestations of our modern era of steel, electricity, and mass production. It is evident, however, that this relation of traffic to tall buildings cannot be completely studied in the case of a single building, or a single class of buildings. It is a neighborhood question, often a regional question. Plainly, for instance, *if* it be essential to the success of a region of tall buildings that widened streets, or subways or elevated structures, be built to carry the users of the tall buildings, then at least some part of the cost of these extra transit facilities is just as really a part of the cost of the buildings as are the elevators within the buildings. This might be said to remain an academic question so long as the subways, etc., paid for themselves by fares collected. But the widened street is a public expense, and the difference between annual receipts from insufficient fares and the total annual cost of a subway is a public expense, and who is to say whether the public gets the proper proportion of this expense back by using the tall buildings, or whether an unfair proportion appears in the form of high land prices in the tall building district?

Mr. Ford was entirely aware that this kind of problem was not solved by the slight investigation on this subject possible for him within the scope of his report. The data as to traffic in relation to buildings of several types are presented therefore primarily for their bearing on the specific subject of the report.

The matter offering the greatest difficulty and difference of existing opinion, however, was something in regard to which Mr. Ford had to choose one method of procedure to the exclusion of others at the very outset. Underlying the whole subject of this research is the question, — do high land values necessitate tall buildings, or do tall buildings create high land values? In one aspect, this question possibly is as futile as the old one as to the priority of the hen or the egg, and is more or less

superficial. In very real sense, however, the question is basic. It may be said that the owner has land of a certain value, on which value he is taxed. He is justified therefore in developing that land to an intensity which will cover these taxes and give him a reasonable return on his whole investment, even if the result is not ideal as a place to live. On the other hand it may be said that the community has a duty to the health and safety of its citizens, and that therefore it should not consider as real values any land prices which can be supported only by an intensity of development plainly detrimental to health.

This controversy, too, Mr. Ford did not attempt to solve. It was obvious, however, that if any organized investigation and thinking at all were to be done on the specific subject of the report, it would have to be on some one basis; that is, some one of the reciprocally interacting factors would have to be chosen as a datum, and the other factors would have to be related to it. Since it was vastly more convenient as regards obtaining data, Mr. Ford chose Land Value as a plane of reference. This however does not mean at all that he has accepted land value as the one fundamental element although it is a governing premise for much of his argument and statistical presentation. It is still possible from this research, up to the limits of its completeness and accuracy, and under present conditions, either to measure health and convenience in its relation to land value, or to measure land value in its relation to health and convenience. Obviously, for instance, if it can be shown that buildings can be constructed on high-priced land which will be both financially successful and satisfactory to live in, and if in the calculations be included *all* costs properly chargeable to the building, whether on the lot, in the street, in a subway, or wherever found, then the high land *price* is a justified *value*. But if a profit to the owner on the land price can be obtained only by, on the one hand, neglecting the health of the occupants of the building or, on the other hand, shifting an expense like otherwise unnecessary subways on to the community without adequate return, then the high land price is something which the community should be loath to perpetuate and defend as a legitimate value.

This report deals mostly with New York because here the conditions discussed are at their present highest manifestation showing probably the greatest good and greatest ill.

The Editor makes grateful acknowledgment not only to those who allowed the use of previous articles and papers which they had prepared, and which here appear as appendices under their authors' names, but

also to all those who freely gave their time in putting at Mr. Ford's disposal the great collection of data on which this report is based.

The research is indebted also to Mr. Cox and Mr. Heydecker for their assistance to Mr. Ford in the discussion of procedure and in the preparation of the report, to Mr. Heydecker again for his permission to use a report appearing as Appendix X, page 132, "Apartment House Study." Above all the Editor is deeply indebted to Mr. Randall for his work throughout the research and his long and careful labor in checking the manuscript, in correcting graphs, and in adding to the manuscript, from notes prepared with Mr. Ford, Appendix XI, page 137, entitled "Discussion of the Apartment House Graphs." Without this help from Mr. Randall, the work of the Editor after Mr. Ford's death would have been practically an impossible task.

H. V. H.

CAMBRIDGE, MASSACHUSETTS
December 1, 1930

PREFACE

With nearly one thousand zoning ordinances in effect — some of them for nearly fifteen years — and with many hundreds of housing and building laws that also regulate the height, bulk, and form of buildings, it is high time that we should take account of stock and try to find out whether the regulations as imposed are attaining the results intended and also whether they are helping or harming the best development of real property.

On the one side we find that during recent years a number of highly interesting scientific studies have been made of the effect of sunlight, light, air, and the lack of these on human beings, as well as congestion both of living or working quarters and of traffic as influenced by the buildings in which people live and work. These studies would seem to prove that our building laws should be radically revised so as to assure some sunlight in every room and also to reduce the bulk of individual buildings.

On the other hand, building owners and managers, real estate men, and those who lend on buildings are insisting that there is great danger of zoning being carried too far, thereby discouraging building and destroying values.

When I was asked to undertake this study, my first thought was that it should take the form of an analysis of a number of typical existing zoning ordinances, to see how they were working out in practice. However, I gradually became aware that the problem was far more fundamental than that, that there was a great unexplored twilight zone in between the point of view of the sociologist on one side and that of the practical building owner and manager on the other side. Nobody seems to have analyzed the recent experience of the more intelligent and farseeing property developers to determine whether or not there is such a thing as an economic or pragmatic approach to zoning. Our study seems to prove strongly that there is such a pragmatic approach, that the best building practice to-day not only warrants, as an economic

necessity, but actually demands a control of height, bulk, and form more drastic than that required by any large city to-day in its existing zoning and building laws.

In making this study I have found it essential to set aside all inhibitions, prejudices, and preconceived notions: to treat it as a pure research, like the solution of an algebraic equation, proceeding logically and inevitably from the knowns to the unknowns. I have made an earnest endeavor to keep entirely away from any academic or philosophical discussion and to stick to the cold facts as brought to light by a thoroughly unbiased investigation.

To that end I searched until I found a man who had exactly the opposite point of view, training, and experience from my own and who at the same time was a research student, one who would not be satisfied until he had the facts and all the facts, regardless of where they might lead. I found such an associate in Mr. A. B. Randall who, as a building economist of repute and a member of the Philadelphia Chapter of the Building Owners and Managers Association, came to this research with a strong skepticism as to the practicalness of any height and bulk zoning. His ingeniousness and persistence in getting pertinent facts and his keen analysis have been of the utmost value in the preparation of this report.

The multiple-housing problem is undoubtedly the most complicated problem from the standpoint of layout and property development that there is. I felt the distinct need of an associate who was not tied down to the current existing types of apartment and tenement house plan. I found such a man in Mr. Leonard Cox, who was the first expert to the New York Tenement House Law Revision Commission and who made the initial studies on which the present multiple-dwellings law was based. His imagination and ingenuity in developing practical layout types and envelopes for multiple dwellings that would answer the economic findings of this research study, have proved of the greatest help.

For the data as to assessed values and taxes I am indebted especially to Mr. Wayne D. Heydecker who kindly allowed the use in this report of his "Apartment House Study" which was made for the Westchester County Planning Federation in 1926.

At every stage of our work we have been both greatly delighted and frankly astonished not only at the readiness but at the eagerness with which building owners and managers, architects, engineers, realtors,

and mortgagees have opened up their books to us and gone out of their way to help us get at the actual facts. It shows a splendid spirit of coöperation and desire to find some way of arriving at a satisfactory solution of this vitally important question.

Of course it is understood that we will keep these data anonymous and guard them carefully in confidence, and we have taken the greatest pains throughout this report to avoid any betrayal of this trust. In most cases, therefore, the names of specific buildings have been omitted.

We owe particular thanks for their helpfulness, among others, to :

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Ely Jacques Kahn, Architect, New York City
Stacy W. Kapp, Civil Engineer, Research Engineer with Fellheimer
and Wagner, Architects, New York City
W. R. Morton Keast, Architect and Economist, Philadelphia
A. Lawrence Kocher, Managing Editor, *The Architectural Record*, New
York City
John L. Laun, Vice President, S. W. Straus and Company, New York
City
John B. Lear, President, Philadelphia Chapter, Building Owners and
Managers Association, Philadelphia
Herbert P. Luce, Lawyer and Real Estate, New York City
Bleecker Marquette, Executive Secretary, Better Housing League of
Cincinnati and Hamilton County, Inc., Cincinnati
Dr. Miller McClintock, Director, Albert Russel Erskine Bureau for
Street Traffic Research, Cambridge

- Yatsuo Matsui, Architect, New York City
 David Merker, Traffic Engineer, Otis Elevator Company, New York City
 Charles F. Merritt, Executive Vice President, Management Division,
 The Real Estate Board of New York, Inc., New York City
 Edward J. Murphy, Real Estate, Springfield
 Arthur T. North, Editor, *The Architectural Forum*, New York City
 Howard M. Nugent, Traffic Engineer, Otis Elevator Company, New
 York City
 John S. Parkinson, Acoustical Engineer, Johns-Manville Corporation,
 New York City
 George H. Payne, Tax Commissioner, City of New York, New York City
 Stanley H. Ross, Engineer, S. W. Straus and Company, New York City
 Richmond H. Shreve, Architect, New York City
 Oliver F. Slimp, Building Manager, Cincinnati
 Lee T. Smith, Real Estate and Insurance, New York City
 Huber E. Smutz, Zoning Engineer, Los Angeles
 W. Howard Stickels, Manager of Educational Services, American
 Institute of Steel Construction, Inc., New York City
 William G. Timothy, General Manager, Saks Fifth Avenue Shop, New
 York City
 Stephen F. Voorhees, Architect, New York City
 Arthur W. Warner, Real Estate, New York City
 H. Hamilton Weber, Rental Manager, Empire State Building, New York
 City
 Kenneth C. Welch, Vice President, Grand Rapids Store Equipment
 Company, Grand Rapids
 Arthur E. Williamson, Zoning Engineer for Los Angeles County, Los
 Angeles
 Eugene W. Yearsley, Electrical and Mechanical Engineer, Otis Elevator
 Company, New York City

In presenting the results of this research study to the public we do it with diffidence and in all humility because we realize that in the short time available it is at best fragmentary. At most it is a series of soundings. Each sounding opens up a whole field of further investigation which should be of the utmost value to the building industry to pursue. Quite frankly, we have been particularly impressed in the course of this study with what seems to be a fact: that the building industry, the greatest industry in the country, is probably the least scientific in its

methods. The determination of height, bulk, form, and layout of most buildings is left entirely to rule of thumb and trial and error. We cannot but believe that an application of scientific methods, corresponding to those in effect in most other industries, of which this report presents a few tentative suggestions, should prove of the utmost value to the building construction and operation field. We are confident further that such studies will prove that zoning has ahead of it a great new field of usefulness by being made to protect the building owner against himself, to safeguard him from economic mistakes.

GEORGE B. FORD

August 1, 1930

BUILDING HEIGHT, BULK, AND FORM

By

GEORGE B. FORD

CHAPTER I

RECENT CONDITIONS AND NEEDS

ARE our zoning ordinances, building codes, and housing laws assuring adequate sunlight, light and air, outlook, privacy, and freedom of movement? Are they at the same time assuring the property owner the opportunity to erect the kind of building that will give him enough return on his equity so that there is a reasonable inducement to build?

On the one hand, many of those who are engaged in the drafting of zoning ordinances and many interested in civic improvement are demanding stricter limitations on the height and bulk of buildings and larger open spaces about them. On the other hand, many building owners and managers, realtors and mortgagees, are insisting that the various building laws must be liberalized or capital will be diverted from the building field and the better class of building will be discouraged.

SUNLIGHT STUDIES

In proof of the former contention may be quoted a series of scientific studies which have been made over the last thirty years, starting with M. A. A. Rey, Mr. William Atkinson, Messrs. Swan and Tuttle, and Mr. Wright, culminating in the very comprehensive and recapitulative studies of Messrs. Heydecker and Goodrich for the Regional Plan Survey of New York and Its Environs.

The results of this long series of studies, which are described in most interesting detail in Volume VII of the Regional Survey of New York and Its Environs, would seem to prove beyond dispute that sunlight and light are essential to good health. They show from an overwhelming mass of testimony that sunlight kills many harmful germs, that it has noticeable effect on morbidity and, in the case of children, a certain effect on the mortality rate. On this premise these latest studies show how the height, bulk, and form of buildings of various classes and types on different types of lots and streets can be so disposed relatively to one another as to assure at least a half hour or more of sunlight in every room,

even on the shortest day of the year. As it is obviously impossible to realize these ideal conditions on higher-priced land, the studies proceed, first, to show how far it is practicable to bring direct sunlight to every window, and second, to indicate that in its health-giving effect light from the sky or "skyshine" or skylight is probably equal to one-third to one-fourth of the value of direct sunlight. The studies go on to show that much depends on the size of windows and their location in the exterior wall and on the depth of rooms, demonstrating quantitatively the obvious fact that large windows, going up almost to the ceiling, and shallow rooms are much healthier than the contrary.

The studies show the great value of north-and-south streets or streets that run as nearly north and south as possible, except in open residential areas where houses are separated. On the north-and-south streets the studies suggest how to avoid entirely all rooms facing north or nearly north, thereby receiving no sunlight.

The studies show too how it is possible to determine the location, size, and shape of towers, even of unlimited height, so that they will not cut off an undue amount of sunlight from neighboring properties.

TRAFFIC STUDIES

The studies also discuss various problems of transit, roadway, and sidewalk congestion, with particular reference to the studies on these subjects made by Dr. Miller McClintock, Mr. J. Rowland Bibbins, and Mr. E. P. Goodrich. Unfortunately, however, these studies on street and transit congestion result in no quantitative method of determining the actual effect of large-bulk buildings on congestion. The subject is obviously capable of much further study. The figures given in the appendices to this report indicate about the sum total of the information which we could find or gain access to on this subject, slight at best.

BUILDING OWNERS' AND MANAGERS' STUDIES

Meanwhile, building owners and managers in most of the larger communities, together with various realtors and mortgagees, have been issuing a series of compilations of facts and of studies showing the actual effect of the zoning ordinances on various typical commercial and residential buildings. They have also been showing for various land values and uses how many net rentable square feet for each square foot of ground area must be had in order to give an adequate return on the equity. The results of these studies have been brought out in a series of reports

and pamphlets published by the National Association of Building Owners and Managers, in particular by Mr. Oliver S. Slimp of Cincinnati, Mr. Louis O. Honig of St. Louis, Mr. W. E. Malm of Cleveland, Mr. John B. Lear of Philadelphia, Mr. Lee T. Smith of New York, and Mr. Earle Shultz of Chicago. As a culmination to these studies a most interesting book has recently been published by Mr. W. C. Clark, of S. W. Straus & Company, and Mr. J. L. Kingston, entitled "The Skyscraper," in which they appear to prove that the economic height limit for a skyscraper on \$100 land under the New York zoning regulations is sixty-three stories, and on \$400 land is seventy-five stories.

ZONING ACCEPTED AS GUARANTEEING OPENNESS

So far the lines of approach to the subject from the point of view of provision of sufficient light and air and from the point of view of maximum rental values have been so diametrically opposed that no fusion seemed to be possible, and yet the pioneer New York zoning ordinance which seemed so utterly drastic when it was first conceived seventeen or eighteen years ago is now accepted currently by builders, even on the highest priced land, as an essential guaranty of at least a minimum of light, air, and openness about buildings.

RECENT INNOVATIONS IN BUILDING FORM

More interesting still are the radical tendencies recently evidenced by a few of the most successful and far-seeing builders, of which the Empire State Building and the New York Life Building in New York are perhaps the most striking examples. In both cases, as a matter of sheer good business and self-protection, the owners have voluntarily given up the great bulk of building which would normally rise directly on the street and they have set their buildings well back from the street lines and lot lines all around above the fifth story, the portion of the rentable area thus foregone immediately above the fifth story being concentrated higher up in towers in the center of the plot, where good light can be permanently assured.

Other developers, who are trying to think ahead and not just follow the usual rule of thumb, are decreasing the coverage for their office buildings or apartment houses to a point well below the usual standards, as they are finding they can get enough more rental per square foot, thanks to the improved light and outlook, to pay them a larger net return on their equity.

OBSCOLESCENCE NOW HEEDED

At last obsolescence is beginning to be recognized for what it is: the insidious disease that destroys building values. Obsolescence means getting out of fashion. The astonishingly quick turnover in skyscraper buildings, the average life being reckoned currently at twenty-five to thirty years, should certainly make us pause. The newest building with more attractive working facilities crowds out its older neighbor and pushes down its rentals. A few builders with vision are trying to see if there is not some way of so designing the office or apartment building of to-day that it will stand the shock of time and continue to hold its clientele and rentals far beyond the time which is current to-day. It is probably with this sort of thing in view that Mr. Raskob, with his architects, Shreve, Lamb & Harmon, has made such a radical departure in his plans for the Empire State Building.

NEED OF COMPREHENSIVE APPROACH TO CONTROL OF BUILDING FORM

In view of these facts and tendencies, we have felt for some time that there must be an entirely new approach to the subject of determining the most effective height, bulk, and form for city buildings. It seemed to us that there must be enough facts, hidden somewhere in the practical experience of builders, to reconcile the seemingly diametrically opposed points of view of the zoning specialist and the building manager. We felt that there must ultimately be data that would prove quantitatively the dollars and cents value of sunlight, light, air, privacy, outlook, and freedom of movement. If such data were available, then it would be possible so to frame a zoning control over height, bulk, and form as to assure the maximum light, air, outlook, and freedom of movement consistent with an assured reasonable return on the investment. *This is the problem which we have set ourselves in this study: to see what the best recent experience of the most intelligent and far-seeing builders would warrant in the way of such control, with a particular view to seeing if the right kind of zoning and building regulations might be employed not only to protect the neighbor, but to protect the rule-of-thumb builder and the blind follower of precedent himself, against uneconomic types of building and too early obsolescence.*

CHAPTER II

PHYSICAL FACTORS INFLUENCING BUILDING DESIGN

SUNLIGHT AND LIGHT

IN starting this study our first job was to clear the decks for action and try to determine what our objectives really were, and to suppress all extraneous considerations or at least to reduce them to their proper place in the scale of relative importance. We soon came to believe that Mr. Lawrence Veiller was largely in the right in his remarkable pamphlet entitled "Light" which he presented in 1929 at the National Conference on City Planning. In this statement he points out that light is far more important than all other factors put together in determining what open spaces should be required about buildings.

Indeed, there is an almost universal feeling that light is one of the most important factors affecting the profitableness and the permanence of larger bulk buildings.¹ It is true that within a few blocks of the Stock Exchange in New York, there is such a demand for space of all types that deep dark space, when parts of offices are at a distance of even fifty to sixty feet from the nearest window, may be readily rented. In this district the usual rate of rental may vary from five dollars to over eight dollars per square foot per year depending on the height above the street, and deep dark space may rent for approximately \$3.50 a square foot per year. However, elsewhere in the city, space over twenty-five to thirty feet in depth from the window will, if rentable at all, command a rental rate of only a third to a quarter of the rate that is obtainable for the other or first-class space. The same is generally true of loft buildings and certainly true of apartments.

The scientific studies of sunlight and light, as made by Rey, Swan, Tuttle, Atkinson, Wright, Swarbrick, and latterly by Heydecker and Goodrich, give some an impression of bearing little or no relation to the practical economics of building management. When we presented these studies for comment to medical and health specialists, such as Dr. Louis I. Dublin of the Metropolitan Life Insurance Company, Dr. Kendall

¹ See Appendix IV, "Light and Sunlight," p. 62.

Emerson of the National Tuberculosis Association, and various members of the Academy of Medicine, we were told frankly that there were so many other contributing factors that it was impracticable to isolate the effect on health caused by the lack of sunlight or light in office buildings or apartments. They all agreed that the therapeutic and the psychological value of sunlight and light in places of work as well as in living quarters was of the utmost importance and should be assured, in so far as it was possible. They did not see, however, any way in which it could be measured quantitatively that would convince a court of justice of the reasonableness of specific minimum requirements as to its amount.

Certain general facts do stand out from these studies so preëminently that we have felt that every endeavor should be made to use them as a basis or a point of departure in determining practical standards for open spaces about buildings. These may be summarized as follows:

- (1) A southern exposure is decidedly preferable to a northern exposure.
- (2) An eastern or western exposure is better than a northern exposure.
- (3) A row building on a street running north and south, with its windows facing east and west, is vastly superior to a building facing north and south on an east-and-west street.
- (4) Courts and yards that open to the south or anywhere around to east and west are far preferable to those which open to the north, east, and west.
- (5) Outer courts and yards are vastly preferable to inner courts unless the inner courts are exceptionally large.
- (6) Although buildings must be nearly twice as far apart as they are high to assure one-half hour of sunlight to every window, nevertheless a well-recognized practice is to put buildings only as far apart as they are high. This is the more defensible, however, in view of the findings of Mr. Heydecker and Mr. Goodrich that direct light from the sky is at least a third as strong in ultra-violet rays as is actual sunlight.
- (7) On this principle is based the restriction that buildings should be no higher than the width of the street or common rear yard space on which they abut, but above this limiting height, buildings could well go higher, provided that they continue to observe this desirable 45-degree light angle.
- (8) There is no objection to towers on office buildings, apartment houses, or hotels, provided that they do not monopolize too large a proportion of the light, and provided in particular that they are located far



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Edwyn Rorke, Architect

enough away from the street lines and lot lines so that there will be plenty of room between neighboring towers for sunlight and light to reach the buildings all around them.

(9) These minimum desirable requirements of light and sunlight should be departed from only in so far as absolutely necessary in order to lay out a practicable building for a given size and shape of lot and for a given land value.

TRAFFIC CONGESTION AND SKYSCRAPERS

As we have said, the result of the considerations just outlined was to convince us that light is the most important factor in determining the amount of open space about buildings. We also arrived at this conclusion by a process of elimination. Take, for example, the problem of traffic and transit congestion. Is it unduly augmented by large-bulk buildings or not? In an appendix¹ we have presented and discussed such facts as we could find available. It is true that surprisingly little study has actually been made of this important subject, but from the facts which are available there would seem to be conclusive evidence that the skyscraper or the massing of skyscrapers and large-bulk buildings does not in itself tend to create any sidewalk, roadway, or transit traffic problem that cannot be somehow taken care of by the provision of additional facilities above or below ground. Of course, however, it remains to be proved in each case whether these facilities are justified by the added building space which they serve. In the first place the counts show that there are few pedestrian traffic problems around large apartment houses. In the case of office buildings and loft buildings, the only pedestrian traffic problems are for a very short peak period when the employees are arriving or leaving or taking a noon hour stroll. In virtually every case any real difficulty that there may be can readily be handled by an arbitrary or often a natural staggering of the times of arriving, departing, and lunch hour. The interesting fact is that the street and transit traffic congestion caused by department stores or theaters is anywhere from two to five times as great as that caused by office buildings or loft buildings; and, what is more, this latter kind of congestion is spread more or less uniformly over a number of hours during the day instead of being concentrated at two or three short peaks. The convenience and economy in a concentration of large-bulk buildings in a small area seem so far to outweigh the inconvenience of the ordinary short

¹ See Appendix I, "Traffic and Building Use," p. 37.

periods of traffic congestion as to make such traffic congestion a minor factor in determining the desirable maximum bulk of office buildings.

SAFETY IN SKYSCRAPERS

Safety in case of panic from fire, earthquake, or other calamity has been much discussed as an academic proposition. We have cited in an appendix ¹ the surprisingly few cases that seem to have occurred where there has been anything even approaching panic conditions in a skyscraper. As a matter of fact, there have been only one or two cases where there has been loss of life or injury and those were in relatively low buildings where the trouble was not in any way due to the building height as such. What people would do in skyscrapers in the case of an earthquake is still problematical, but surely there is nothing in our experience up to date that would warrant our limiting height in order to make the buildings safer. This statement could be qualified somewhat with regard to apartment houses on account of the presence there of children, old people, invalids, and dependents, although even there the descent of twelve to fifteen stories of stairs in a smoke-proof tower, even should it be necessary, is not at all impractical except for a very limited few.

DUST, GASES, AND NOISES

Dust, smoke, automobile gases, and noises do have some influence on the skyscraper problem, but almost exclusively in favor of the skyscraper. The available facts on these four items are discussed at some length in an appendix.² According to tests made by the city and federal health departments, noise from the street decreases very little until a building rises above its neighbors and then the noise drops down markedly and becomes the general roar of the city. The quietness of tower offices accounts in some measure for the high rentals which so many people are willing to pay for them. Tests show that even the setbacks decrease noise in offices for one to three stories above, although no additional rent can be secured from an office behind a setback on account of the dust and reflected heat from the terrace roof. On the other hand, in the apartment houses and apartment hotels a setback terrace often brings a double rental value for the apartment behind it.

Automobile gases, especially carbon monoxide, are prevalent, sometimes in dangerous quantities at the street level. Such gases are heavier than air in most cases and therefore the air becomes rather purer and safer to breathe as the office or apartment rises higher above the ground.

¹ See Appendix II, "Safety and Egress," p. 49.

² See Appendix III, "Dust, Gas, and Noise," p. 52.

Smoke and dust both tend to sift down toward the street, and the dust counts show that the proportion of dust particles in the air decreases very rapidly as one mounts above the street, with the result that in towers the air approaches the purity of country air. This, again, is an argument in favor of a taller building.

WIND AND AIR AMONG TALL BUILDINGS

Wind and the circulation of air have no material effect on the skyscraper problem. Wind-bracing adequate to meet a hurricane is a commonplace in skyscraper construction. The wind abrasion and the loosening of decorative features on the exteriors of taller buildings is an item in the upkeep of the skyscraper but it can be largely overcome by proper provision against it in the original construction of the building. It is not a large item at worst.

The circulation of air among tall buildings and in yards and courts is not a serious problem in winter because the windows are largely closed anyway. In summer, with the windows open, there is a circulation through the buildings into or out of the yards or courts so that the latter become flues, which of themselves accelerate the circulation of air. Of course there is the problem of gusty winds in the canyon-like streets among skyscrapers. While it is inconvenient sometimes, it is virtually never dangerous and it often does assure a flushing of air in the streets in the hot and sultry days of summer that would hardly exist if it were not for the skyscraper canyons.

OUTLOOK AMONG SKYSCRAPERS

As to outlook, — the chance of enjoying a view over the green of nature, — and as to the possibilities of recreational areas, the skyscraper and the large-bulk building do have a certain harmful effect. They also tend to diminish privacy and to produce a sense of being shut in. In any case it all comes down to a matter of having more open space opposite windows, as far as office buildings and most apartment houses are concerned, and it is fair to assume that if the open spaces opposite windows are adequate for proper light, they will also prove adequate from the standpoint of outlook, privacy, and a sense of openness. In certain apartment and tenement houses, where trees or recreation areas are desirable, it is usually possible so to arrange the layout of the building as to combine the various yards and courts, required for light, so that they will together create a park or playground within the periphery of the building.

CHAPTER III

METHODS OF DETERMINING OPTIMUM BUILDING MASS

ANALYSIS OF BUILDING MANAGEMENT DATA

WE next proceeded to analyze the great mass of new and most practical data which was given us so generously by various of the leading building managers, realtors, and mortgagees, mostly of New York and Philadelphia. A digest of these data is presented in an appendix with graphs and tables.¹ As most of these data were given us in confidence we have been obliged in most cases to omit any mention of the specific buildings to which the data applied and occasionally even to omit certain figures or plotted points on some of the graphs that would serve to identify specific buildings. However, we can say without qualification that all of the data in the report and all of the graphs and tables are drawn directly from specific and carefully selected data, and in every case the data have been chosen fairly and not selected so as to prove any preconceived theory. In other words, we made every attempt to make this a true research, a search for the facts wherever they may lead.

The article which was prepared by Keast and Randall for the April, 1930, number of *The Architectural Record*, entitled "The Minimum Building for Varying Land Values," suggests a method for determining scientifically whether a given proposed office building should pay or not. This method has been described in some detail in an appendix.²

We have used these studies as a point of departure in determining how large a building and what kind of building will be needed on a given plot at a given land value in order to provide a reasonable return on the investment.

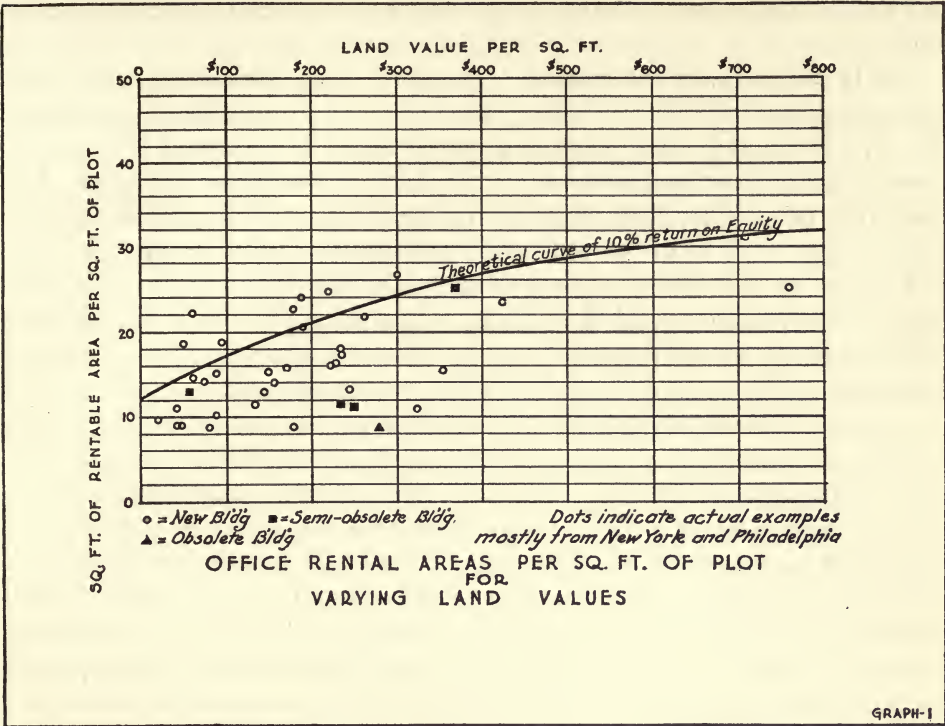
CALCULATION OF MAXIMUM BUILDING BULK

In an appendix table³ entitled "Table of Calculations Showing a Method of Deducing What is the Minimum Building for Varying Land

¹ See especially Appendices V through XI, pp. 74-162.

² See Appendix V, "The Most Profitable Building on Varying Land Values," p. 74.

³ See Table VIII, p. 93.



Values,” we show in the eighth line the total net rentable floor area in square feet, exclusive of the ground floor, that will be needed over each square foot of ground area in order to assure a 10 per cent net return on the equity in office buildings. We have assumed a 10 per cent net return on the equity, as there seems to be a preponderant opinion among developers that anything less than that will not attract new capital into larger building operations on account of the risk involved. An examination of these figures shows that on land at \$100 a square foot a 10 per cent net return on the equity will require sixteen and one-half net rentable square feet for each square foot of ground area. As the average well-designed building covers about 70 per cent of the lot and as the net rentable area on a typical floor should be about 70 per cent of the building area, the net rentable area on a typical floor would only average about a half of the ground area. On this basis, the sixteen and one-half net rentable square feet for each foot of ground area would occupy thirty-three stories, and if a tower is confined to a quarter of the area of the lot the required thirty-three stories might well be forty stories or more. Accord-

ing to the same table, a building on \$350 land would have to be half as high again.

It is particularly interesting to compare this calculated ratio with the actual facts for fifty or sixty typical skyscrapers, as shown in Graph No. 1. It is noteworthy that this curve, drawn from actual facts taken from existing buildings, almost exactly corroborates the calculated rentable area per square foot of plot, as given in the table¹ just described. This would tend to prove still more convincingly that the 10 per cent net return on the equity is a reasonable allowance, from the standpoint both of the owner and of the public. This means normally a return of 7.445 per cent on the total investment, after all allowances are made for financing costs, carrying charges, initial vacancies, obsolescence, etc.

In order to make sure that we were giving the owner complete protection we conducted a series of arduous calculations to see if there were such a thing as a maximum return on the equity for each class of land value. The method used in these calculations and the conclusions are described in detail in an appendix.² The results of these calculations are shown on Graph No. 2. This graph shows that on \$100 land the maximum possible return would be a building where the net rentable square feet per square foot of ground would be about 33, which would imply a 66-story building. Curiously, this almost exactly corroborates³ the findings of Mr. W. C. Clark in his book, "The Skyscraper." The same curve shows that on \$300 land the maximum possible return would be on a building a little over eighty stories in height.

The same calculations show, according to Graph No. 2, that the ratio of building cost to land value for 10 per cent net on the equity would be 1.30 to 1.00 for \$200 land, or a building cost of \$1,300,000 on land worth \$1,000,000. On the same land a maximum-return building would cost \$2,400,000. The interesting part of all of these curves is that they flatten out on very high land values. In other words, we are reaching a practicable peak in our highest land values per square foot and there is no excuse, considering current rental rates, building costs, and other conditions, for land to be worth over about \$600 a square foot anywhere.

Time was lacking to make a similar calculation for apartment houses. (In fact, it would involve hundreds of hours of close calculation.) However, we have prepared a graph, No. 62, from authentic data, which is

¹ See Table VIII, p. 93.

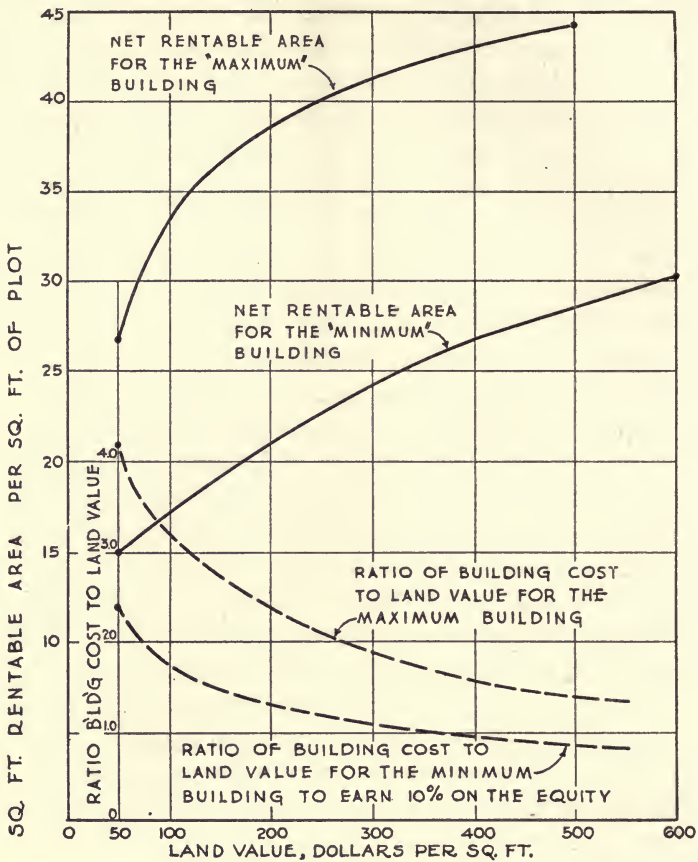
² See Appendix V, "The Most Profitable Building on Varying Land Values," p. 74.

³ These estimates would check even more closely had the latter included financing charges and costs of initial vacancy.

entitled "Square Feet of Rentable Area per Square Foot of Plot with Varying Land Values for Apartments." According to this curve, on \$5 land three square feet of rentable area per square foot of plot are needed for a 10 per cent net return. On \$10 land four and one-half square feet are needed. On \$20 land six square feet of net rentable area are needed; on \$40 land, eight square feet. Again, as in the case of office buildings, if the apartment house, as is customary to-day, covers about 70 per cent of the lot area, and the net rentable area covers about 70 per cent of the building area, then six square feet of net rentable area on \$20 land would have to be spread over about twelve stories, and on \$40 land it would reach sixteen stories. As most apartment houses are built on land worth less than five dollars a square foot, and even in the heart of Manhattan they are on land worth less than fifty dollars a square foot, it is very difficult to find available examples to check our projected curve within the region of high land values. In general, however, the curve would seem to indicate that on \$100 land eleven square feet of net rentable area for each square foot of land would be about right, and on \$200 land the ratio would reach a peak at about thirteen square feet of net rentable space. In other words, a 26-story building, or with a tower a 30-story building, would be maximum. Conversely this would mean that \$200 is the limit in value for land to be used for residential purposes even in Manhattan, and in fact there is very little advantage in building even a highest-class apartment building on land worth over forty to fifty dollars a square foot. The normal high-grade suburban apartment would seem to be hardly profitable on land over five dollars per square foot. Most suburban and garden apartments are on land worth about one to two dollars per square foot.

DISTRIBUTING BUILDING BULK

So far we have devoted our attention to finding a quantitative method of determining the minimum practicable bulk of office and apartment buildings. The next and even more important problem is that of finding how to distribute that bulk on any given lot and for any given land value so as to determine the height and form of building that will be of the greatest permanent advantage to the tenant, to the owner, to the neighbors, and to the general public. To that end we have analyzed the available data, first as to the customary increase in rental rate per square foot with the distance above the base of the building, and second, with regard to the differential in the rents due to exposure and outlook



GRAPH SHOWING THE RENTABLE AREA PER SQ. FT. OF PLOT REQUIRED FOR THE MAXIMUM BUILDING ON A VERY LARGE PLOT, AND THE RENTABLE AREA REQUIRED FOR THE MINIMUM BUILDING TO EARN 10% ON THE EQUITY INVESTMENT. RATIO OF BUILDING COST TO LAND VALUE FOR EACH CASE IS SHOWN DOTTED.

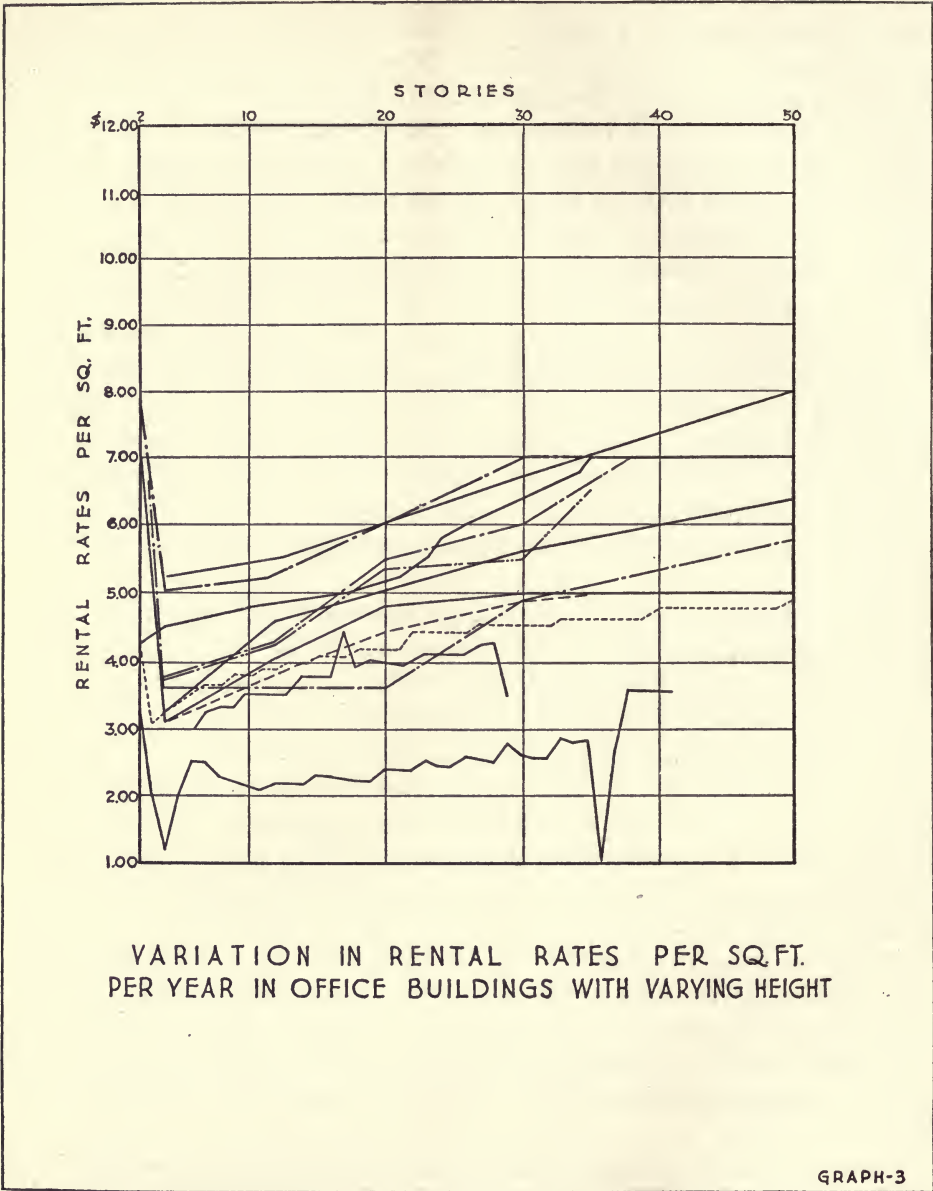
OFFICE RENTABLE AREA PER SQ. FT. OF PLOT FOR 10% AND MAXIMUM RETURN ON EQUITY

GRAPH-2

Two accompanying graphs (Nos. 3 and 4), one for office buildings and the other for apartment houses, are drawn in each case from a fairly selected number of typical examples. The trend is surprisingly uniform in both cases. In the office building (Graph No. 3) we find that the square-foot rental rates increase, on the average, almost exactly 1 per cent per story, reckoning the rent of some one floor, usually the third, the fourth, or the fifth, as being 100 per cent as a basis from which to start. The tendency in recent buildings is toward more nearly $1\frac{1}{4}$ per cent per story. In at least five or six typical buildings in the Wall Street district, the rate approaches 2 per cent per story. In other words, in a 50-story building the rental rate per square foot at the top of the building is nearly double that at the third story. In any case, it is most obvious that light and outlook command a marked premium, and that anything which will bring more of the upper light and openness down into the lower stories will correspondingly increase their rental value. In other words, it is practicable to make a considerable sacrifice in building bulk in the lower stories, provided a sufficient proportion of it is added to the tower.

The cost per cubic foot of buildings increases with the height, obviously. The figures prepared from actual estimates by leading builders and shown in "The Skyscraper" are plotted in Graph No. 44. A cubic foot in an 8-story building would cost $53\frac{1}{4}$ cents. It would cost $55\frac{1}{8}$ cents for a 22-story building, $63\frac{1}{2}$ cents for a 50-story building, and $70\frac{1}{2}$ cents for a 75-story building. This is an increase of only 50 per cent, whereas the increase in the rental rate per square foot, according to the preceding graph, would be at least 70 per cent and from that up to a maximum of 140 per cent. In other words, the differential in rental rates for skyscraper towers is at least half as large again and often two or two and one-half times as great as the differential in cubic foot cost of the higher building. From figures which we gained from other sources, which appear to corroborate the cubic foot cost calculations as given in Mr. Clark's book, we believe these conclusions can be deemed to be reasonably accurate despite the fact that the tallest buildings are usually made to cost more than here shown.

In many of the higher buildings are included the costs of large and imposing banking rooms, or costly construction for some special commercial use, including such items as safe deposit vaults and the like. It was found almost impossible to get such costs deducted from the other building costs without going through all the detailed contract estimates

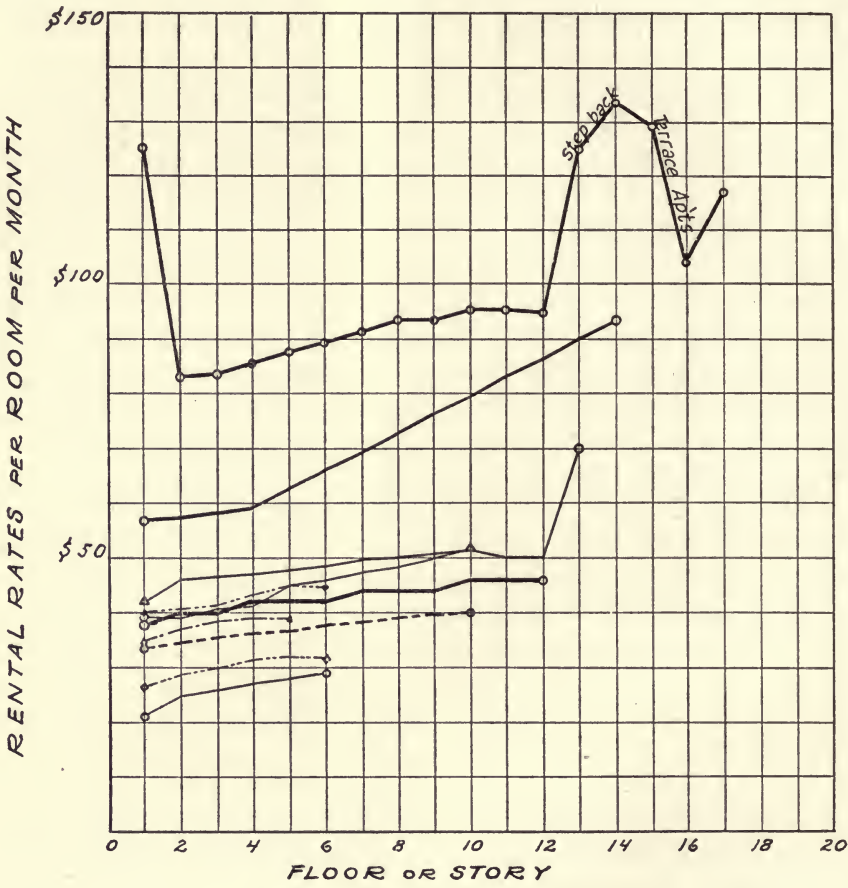


of the building. However, knowing approximately the costs of this type of work, as based on one typical building where we had all the data, an estimate was made and the approximate costs of the buildings without these items were set up. It is not proper to attribute to the building the costs of these expensive changes for tenants or special owners when we are seeking to determine the influence of height alone on costs.

The number of buildings over fifty stories in height is small, and the plotting of the points would violate confidences since these buildings would be too easily identified by an observer. The points were all plotted and a trend drawn as fairly representing the facts thus obtained, but the trend alone is reproduced.

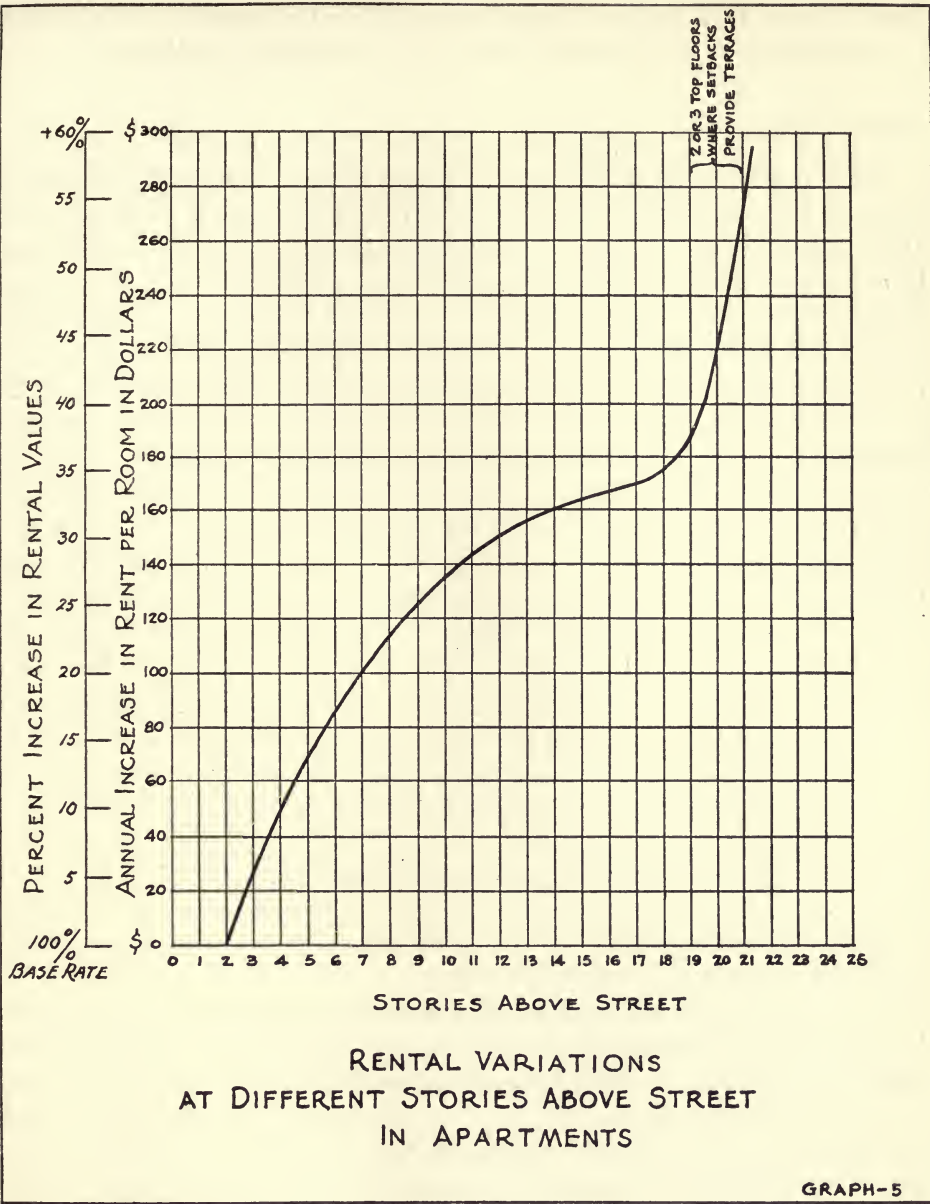
The curve plotted from the results of the published Clark-Kingston study appears to commence a sharp increase in cost above the sixtieth story. Unfortunately their estimates stop too soon to assure that this sharp increase will continue, although it is most probable that it will. An experienced architect believes that this cost will progressively increase above this level, but from the conditions of the other buildings on which data are obtained, this fact is not yet fully substantiated.

When we come to high apartment buildings we find that much the same thing holds true. Graph No. 4, "Rental Rates per Room per Month with Varying Heights in Apartments," again taken from a number of typical apartment houses, shows that rentals tend to increase at the rate of about $2\frac{1}{2}$ per cent per story. Graph No. 5, "Rental Variations at Different Stories above Street in Apartments," which is a composite of a number of rental schedules, shows a little over 3 per cent increase per story up to the eighth floor, and then the percentage rate of increase gradually decreases until it almost disappears at about the sixteenth to eighteenth floor, except for penthouses and step-back terrace apartments. The increase in cubic cost per story of added height runs, according to Graph No. 43, from about 65 cents a cubic foot for a 10-story apartment building up to 80 cents a cubic foot for a 30-story building. The differential below ten stories is comparatively slight down to six stories; but below six stories, thanks to semi-fireproofing requirements, it drops rapidly to 55 cents and even below 50 cents a cubic foot and to 35 cents and 40 cents for non-fireproof walk-ups. The comparison of the cubic cost differential rate with the rental differential rate according to height shows again that the rentals tend to increase faster than the building cost, up to sixteen or eighteen stories in height, and above that level construction



RENTAL RATES PER ROOM PER MONTH
WITH VARYING HEIGHTS IN APARTMENTS

GRAPH-4



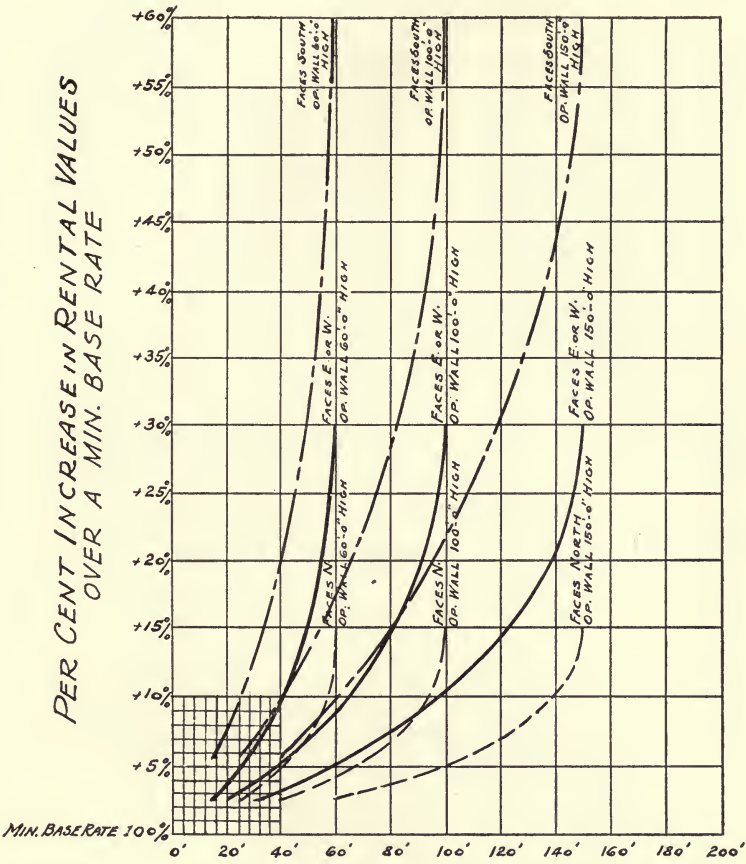
cost would in most cases increase faster than rentals, all of which would tend to prove that sixteen to eighteen stories is the economic height limit for apartments in the largest cities, except for special penthouses.

RENTALS VARY WITH EXPOSURE

That rentals vary with exposure and outlook is proved by the figures presented in an appendix.¹ It was not found practicable to present the differentials in graph form. Nevertheless southern exposure commands from 10 per cent to 40 per cent more than northern exposure. Street frontage normally commands from 10 per cent to 50 per cent more than court frontage; large rear yard exposure will permit of rentals at least 10 per cent more than could be secured on a court. The wider the court or yard, the higher the rentals. While it was found impossible to reduce these data to any very tangible form, nevertheless a perusal of a large number of apartment house plans and renting schedules has led to the preparation of Graph No. 6. This graph, "The Curves of Rental Value Variations with Different Exposures and Different Heights and Distances of Opposite Walls," shows that where an opposite wall is about forty feet away and sixty feet high, to the south, we could expect an increase in rental values of about 20 per cent over a minimum base rate fixed by the poorest allowable open space. At twenty-five feet away the increase would be not over 10 per cent. At best these particular figures need further facts to support them, but unquestionably a rearrangement of the form and the bulk of the building so as to permit better exposure and outlook does add materially to the rental rate that can be demanded. This is particularly brought out in cases where to-day enlightened and astute apartment operators and planners are constructing buildings covering a lesser proportion of the plot and with a lesser cubic volume than was the previous general custom.

Two plans, Graph No. 7, are compared for the same interior 100 × 100-foot lot. Plan A is a typical tenement house law layout covering 70 per cent of the lot area. Plan B has sacrificed over 20 per cent of the plot or area built upon in order to secure much more light, air, and outlook to the apartments. As figured and estimated by Mr. Leonard Cox, the result is a difference of only 4 per cent in the total rental schedule of the two buildings, whereas there would be a saving of nearly 15 per cent in the cost of the more open building.

¹ See Appendix VI, "Rentals Increase with Height and Exposure," p. 87.

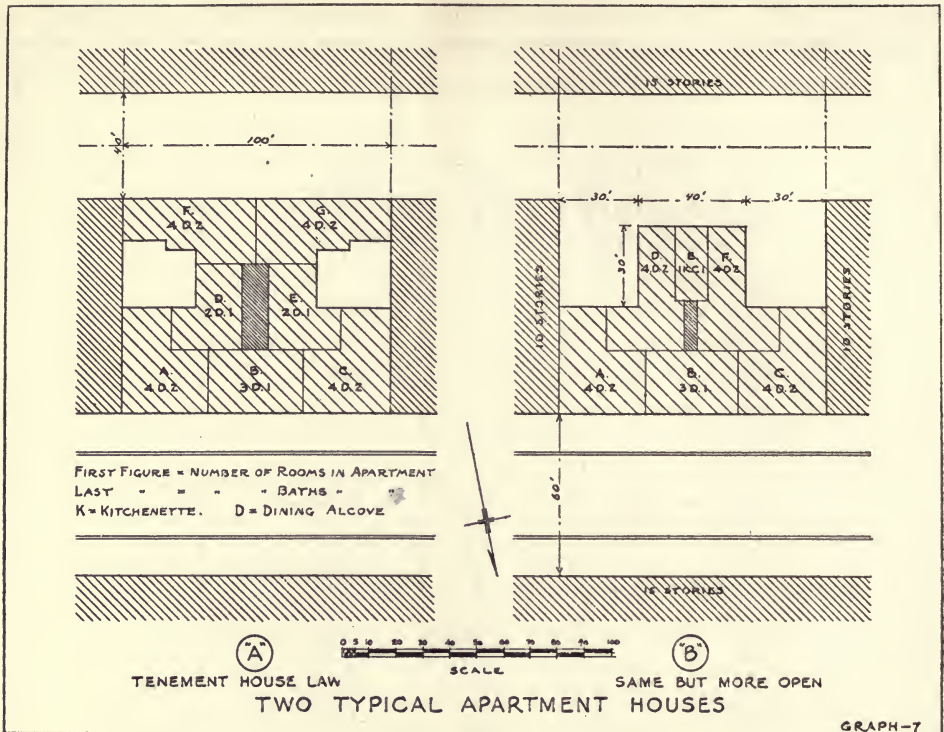


DISTANCE OF OPPOSITE WALL

CURVES OF RENTAL VALUE VARIATIONS WITH DIFFERENT EXPOSURES
AND DIFFERENT HEIGHTS AND DISTANCES OF OPPOSITE WALLS

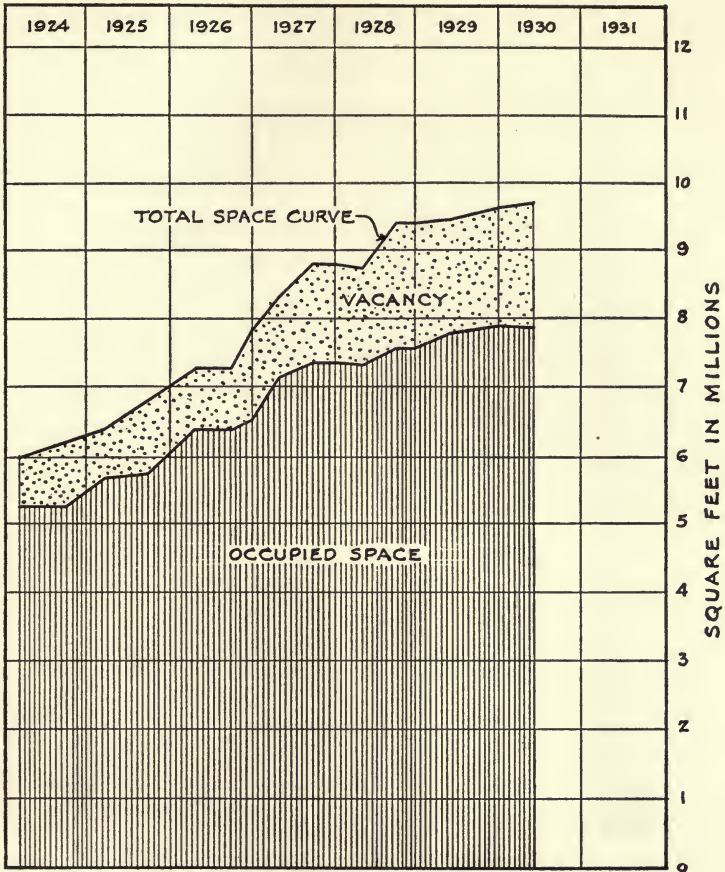
RENTAL VARIATIONS WITH EXPOSURE IN APTS

GRAPH-6

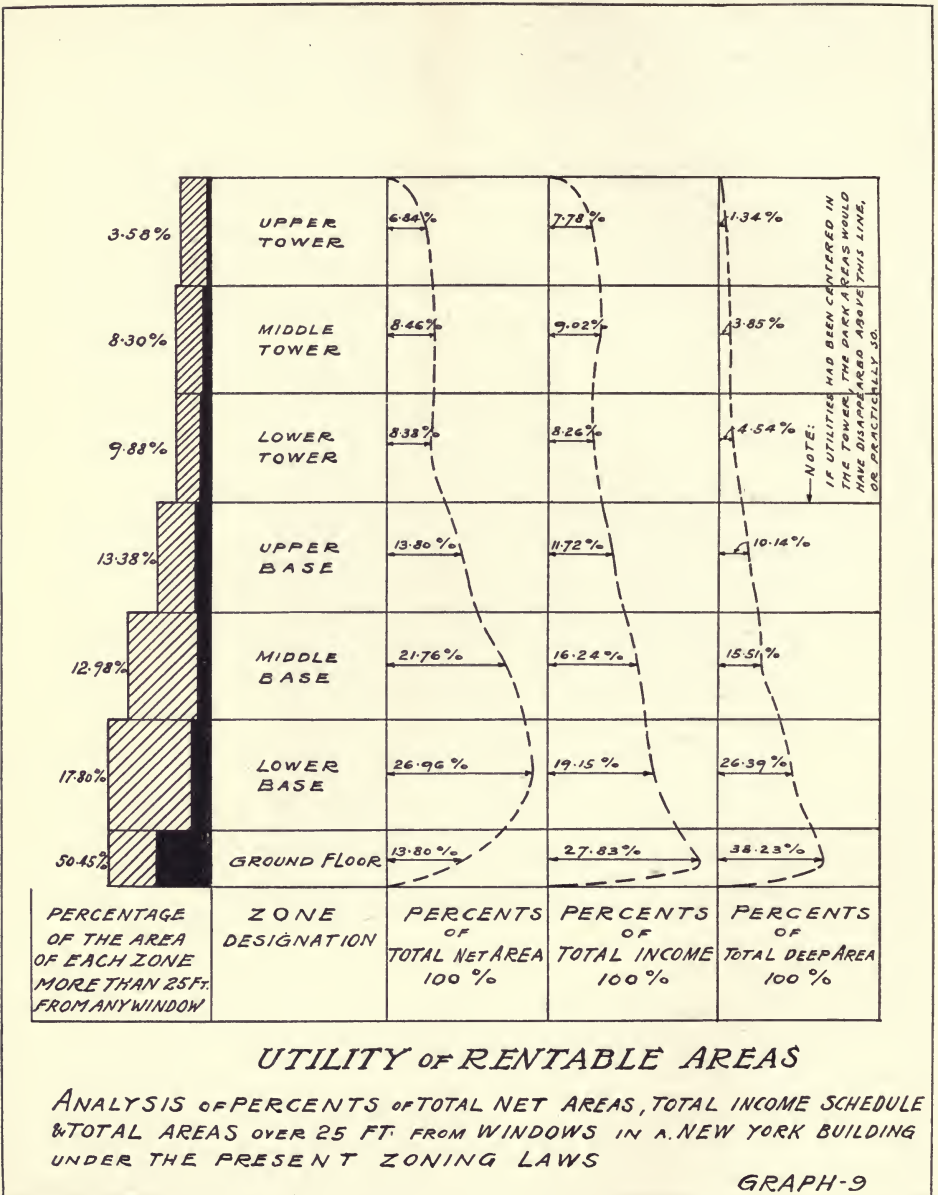


EFFECT OF VACANCIES

When we come to apply these principles to actual working conditions the market becomes the controlling factor. The best index to the market is shown in Graph No. 8, "Office Absorption and Vacancy in a Typical Large City." Data which we have been permitted to see, with regard to vacancy in several of the largest cities, corroborate this curve. The striking part of it is that the amount of the vacant area in office buildings has more than doubled within the last six or seven years. The percentage of vacant space in proportion to new building during the same period has increased several times. Still more striking is the fact that the total amount of vacant space in office buildings to-day is as great as the total amount of new space constructed during the last five years. The conclusion is obvious that it is a buyer's market. A client can afford to be particular and to demand something more than just space. The result, as borne out by the facts, is that the space with the best light and the best exposure is taken first. In other words, light, exposure, and out-



OFFICE ABSORPTION AND VACANCY
IN A TYPICAL LARGE CITY.



look are at a premium, and what is true of office buildings is nearly true of apartment houses.

WASTE BULK AT BASE OF SKYSCRAPER

This brings up another interesting point that is best illustrated by Graph No. 9, "Utility of Rentable Areas." Assuming that twenty-five feet is a normal economic depth for an office, this graph shows that 80 per cent of the excess depth over twenty-five feet is in the lower half of a typical recent skyscraper, two-thirds of the excess depth is in the lowest third of the building, and nearly 60 per cent is in the lowest sixth. Again when we come to compare the income with the net rentable area we find that starting with the third floor, 27 per cent of the total rentable area of the building is in the lowest sixth of its height and that the income from this same lowest sixth is only 19 per cent of the total. The next lowest sixth of the height has 22 per cent of the rentable area and returns only $16\frac{1}{4}$ per cent of the income. In other words, the bulky lower stories of the typical skyscraper are much too heavy to row their own weight. They are a drag on the building and tend markedly to cut down the net return on the equity for the whole project.

It is this fact, that has only lately been understood, that is now leading various of the more far-sighted building owners and managers to declare that it is an economic fallacy to put such a large proportion of the net rentable office space on the lowest floors, where the rentals per square foot are often only half those which can be obtained in a tower. It is exactly this principle that has led the owners of the Empire State Building to carry their tower all the way down to the fifth story and cut back the building all the way around above that story, just as had been done previously in the New York Life Insurance Building. In fact, it might well be good strategy to bring the tower down still lower, even down to the top of the second or third floor, unless there was an obvious market for the first four or five stories for department stores, specialty shops, banks, brokers' offices, insurance offices, and the like, with their work rooms directly over their sales rooms and their public rooms. So true is this principle, except possibly within a block or two of a Stock Exchange, where even dark interior office space is always in demand, that there would seem to be a rapidly growing consensus of opinion that it is good business to bring towers down to the fourth or fifth story on almost any property, provided of course that the bulk given up in the lower stories can be added to the tower.

Despite the difference in the problems the same principle seems to apply equally well to apartment houses and hotels, where again space higher up is worth enough more than space near the ground to warrant cutting back the building nearer the ground and letting it run up higher in the air instead.

MORE OPEN SPACE OPPOSITE LOWER WINDOWS

This brings us to the serious problem of how to get more open space opposite the lower windows of an office building or apartment house. For the windows facing directly on streets the problem is not so serious, as the step-backs in the upper stories of buildings in most of our city zoning ordinances already go a long way toward furnishing a practicable solution. The chief difficulty is on the sides and rear, where blind custom currently provides only a fraction of the light, exposure, and outlook that is afforded on the streets. If office and apartment space with good light, air, and outlook is actually worth so much more than space with poor light and exposure, then it is obvious economy to create larger — in fact materially larger — open spaces, particularly on the rear and sides of buildings.

LARGER COURTS

The most logical first step is to eliminate the inner or enclosed court unless it is large enough so that it corresponds in its light and exposure to a rear yard. An outer court facing preferably on the street, but otherwise on a large rear yard, should, if wide enough in proportion to its height and length, be far more satisfactory than an inner court. It has been the custom to think that inner courts were essential and that many office buildings and most apartment houses could not be designed properly without them, but that was based on the assumption that maximum coverage, and maximum coverage alone, was what gave the best permanent return on the equity. To-day, now that quality and not quantity has become the watchword, the old rule-of-thumb argument for the inner court no longer obtains. An examination of the recent plans for new apartment houses, as laid out by the most successful developers in New York and Philadelphia, reveals surprisingly few inner courts, or where they are retained they are large enough to put outlook over them, together with the privacy and quiet which they offer, at a premium.

This leads to the suggestion that apartment houses as well as office

buildings should be set back from all side and rear lot lines above the fifth or sixth stories, that is above sixty feet above the curb, or a height equal to the width of the average street. At first this may seem like a too radical suggestion. Nevertheless if there is any one thing that stands out clearly from the calculations in this research and from the recent experience of the more progressive building owners and managers, it is that it is good economy to substitute quality for quantity space in the lower part of city buildings. In one case this seemingly radical proposal was volunteered by an astute manager of many dozens of apartment houses, without any suggestion by the investigator. Obviously in the smaller city or town where land values are relatively low, there is no economic need for skyscrapers and therefore this problem hardly exists. It is also true that on many lots, due to their variance or their peculiar shape, side yards are found to be impracticable and towers would be economically impossible. All of these special cases would have to be handled, as they are in most zoning ordinances, by special exceptions or by special action on the part of the zoning board of appeals.

LIGHTER YARDS AND COURTS

The various scientific studies of sunlight and light all agree in their insistence that a southern orientation of the windows, or one that approximates south, is far more effective in bringing sunlight and light into a room than any other direction of aspect. Experience in various recent zoning ordinances is seeming to prove that it is practicable in open rural or suburban residential districts to require enough space between buildings to assure sunlight in every room. In the recommendations which follow for garden apartments and for open construction, the ideal provision for sunlight and light is closely approximated and it is done in a way that would seem to make it economically practicable.

When we come to a more closely built-up residential or business development, the facts appear to prove that economic conditions make it impossible to assure the ideal sunlight and light. All that we can do is to approach the ideal as nearly as practicable. Where we can lay out a new tract it is possible so to orient the streets and buildings as to provide uniformly for courts and yards opening to the south, as well as streets which run north and south; but in areas already plotted it appears to be virtually impossible to find any practical way of requiring a southern exposure to all yards and courts. Obviously, the only alternative is to make the yards and courts as open as possible. A working ideal that

has been approached to a greater or less degree in most zoning ordinances is to try to keep down the height of buildings to the widths of streets on which they abut and, at the same time, try to make the common rear yard space in the center of the plot at least as wide as the street; and to make the courts, all of which should face on the front or rear yard, each as wide as possible. The inner court, enclosed by four walls, admits enough light to its lower windows only when it is exceptionally large in area. It is a well-known fact that an outer court, although much narrower than a corresponding inner court, can bring much more light to its lower windows than the inner court, especially if it faces on a street or on a large rear yard.

CHAPTER IV

RECOMMENDATIONS

TENTATIVE RECOMMENDATIONS

MORE specifically, we offer the following tentative suggestions for the regulation of the height, bulk, and form of office and apartment buildings. We do this with the understanding that these recommendations must be subject to a vast amount of further study and application to conditions of all sorts before they can be pronounced workable in practice. We believe, however, that they will go much further than any existing zoning ordinances, building codes, or housing laws in assuring a desirable minimum of sunlight, light, air, outlook, and privacy and at the same time prove more practicable and even more profitable from the building owner's standpoint.

We have accompanied our suggestions with a table¹ on which we have shown comparatively the height, step-back, tower, and yard and court provisions of the zoning ordinances of eight typical cities: New York, Chicago, Pittsburgh, St. Louis, Cincinnati, Dallas, Providence, and Springfield, Mass. The recommendations and table follow:²

FOR OFFICE BUILDINGS

(1) No inner courts should be allowed unless they are as large as two back-to-back rear yards.

(2) Rear yards should be of at least twenty feet minimum depth and they should increase in depth one foot horizontally for each two feet of height above the bottom of the yard in an open zone, up to a ratio of one to four in the most unrestricted zones.

(3) Outer courts should increase in width with their height in one-half the ratio of rear yards, but they need to be only ten feet wide minimum at the lowest window served.

(4) Side yards should be required on all lots, starting at a height above the ground equal to the street width, their minimum width to be

¹ See Table I, pp. 34-35.

² See also building envelope diagrams, pp. 163-179, based on these recommendations.

ten feet and then to increase in width like outer courts up to a maximum of forty feet.

(5) The step-backs and gable provisions should remain as in New York City and other similar zoning ordinances.

(6) Towers should be allowed to go up to twice the maximum height allowed on the street line, without any restriction as to area except that no part of a tower should be within fifty feet of the center line of any street and should keep away from all lot lines according to the side yard requirements. Where a wall of a tower is more than eighty feet in length, for each foot of such greater length three inches should be added to the required distance away from the lot lines. Above the height of double the street line height limitation, towers could still continue upward, provided they only covered 25 per cent of the lot area and still kept at least forty feet away from all lot lines.

FOR APARTMENTS

(1) Inner courts should be eliminated, unless as large as two rear yards back to back.

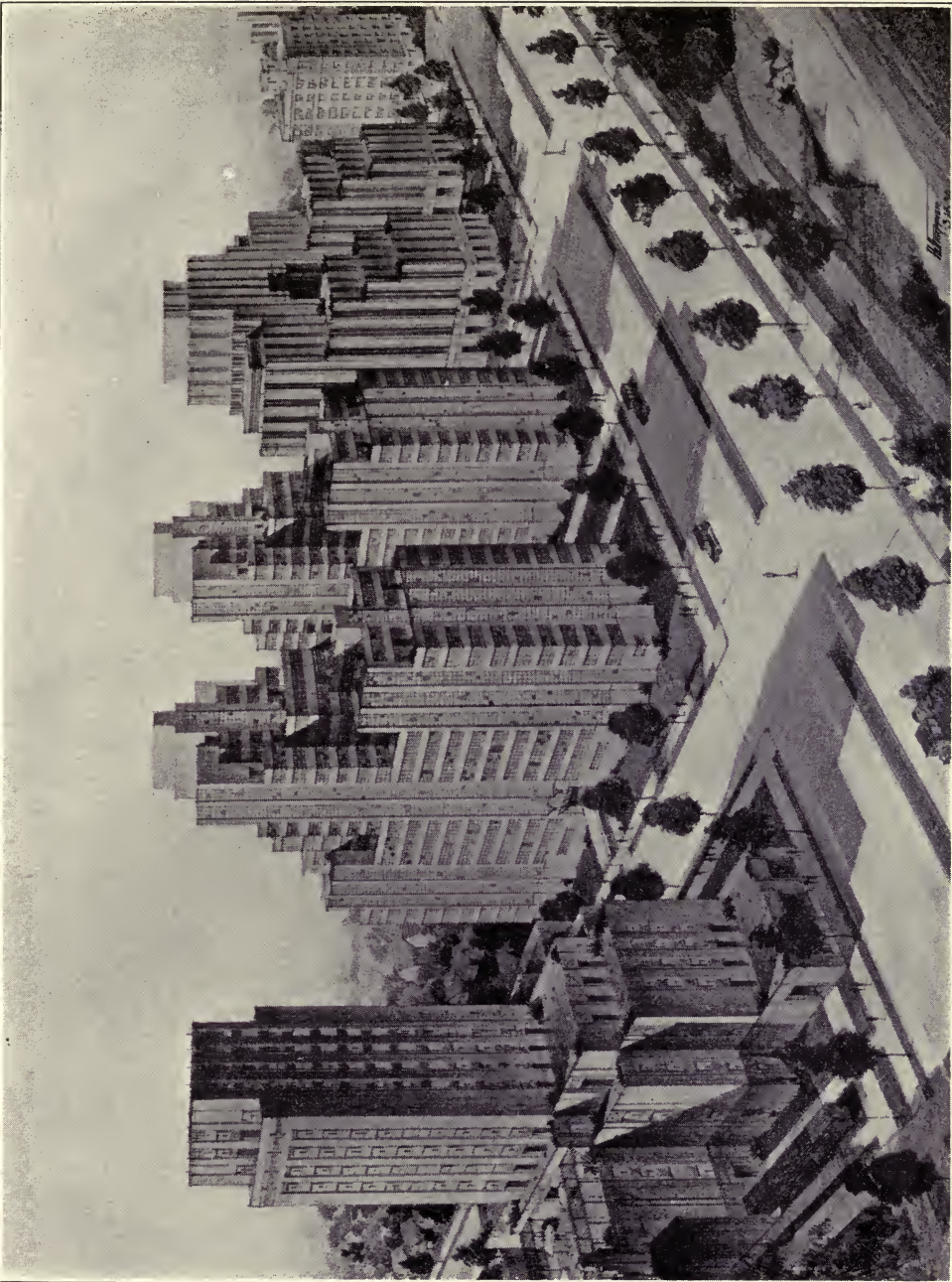
(2) Outer courts should be at least fifteen feet wide. Court widths should increase with height in the ratios of one to four and one to six, depending on the zone.

(3) Side yards should be required on all buildings to start at a height above the street equal to the width of the street. Their minimum and increasing widths should be the same as those for outer courts.

(4) Rear yards in a less intensive zone should be at least thirty feet deep and increase at the rate of one foot horizontally to two feet of height. In a more intensive zone the rear yards should be at least twenty feet deep and increase in a ratio of one to three.

(5) Step-backs should be in the ratio of one foot horizontally to two feet vertically, and in the ratio of one to three, as provided in the zoning ordinance of New York and other cities.

(6) Towers in a district where the buildings are as high as the street is wide should rise to a total height of one and a half times the street width; in a more intensive district, to two times the street width. No part of any tower should be within fifty feet of the center line of any street, nor should it be within less than forty feet of any rear lot line, nor within less than twenty feet of any side lot line. For every foot that a tower wall is more than forty feet in length, three inches should be added to the twenty-foot distance from the side lot line.



Photograph by Peter A. Juley & Son from drawing by Arthur J. Frappier

George B. Ford, Architect

PROPOSED END-ON APARTMENTS FACING THE WATER OR A PARK

A suggestion for carrying frontage values down the side street and into the block interior

(Reproduced by permission of Regional Plan Association, Inc.)

FOR GARDEN APARTMENTS

(Of the type that is now developing so rapidly in the suburbs of the larger cities)

(1) The total gross floor area of all floors should not exceed the area of the lot.

(2) No part of any building should be within fifty feet of the center line of any street.

(3) Rear yards should be at least thirty feet deep and they should increase in the ratio of one foot horizontally to one foot of height.

(4) Side yards are required, and they and any outer courts should be at least fifteen feet wide, with an increase of one foot horizontally to each two feet of height.

As will be seen from an appendix,¹ the average coverage of about thirty of the most recent apartments in New Rochelle and other Westchester towns is 42 per cent of the lot areas. A number of the most successful recent apartments cover 30 per cent, 25 per cent, and even 20 per cent of the lot area. The above provisions would mean that a four-story garden apartment would cover 25 per cent of the lot area per average floor, and the six-story apartment, 16 $\frac{2}{3}$ per cent, — all of which is proving entirely practicable with land values not exceeding one to two dollars a square foot. As a matter of fact, there are already at least half a dozen zoning ordinances in effect in the New York Region which are operating successfully under provisions similar to this. In particular, one of the most striking examples of this tendency is that of the Alden Park Manor apartment houses near Philadelphia, four of them eight to ten stories high, set in a park of many acres. (See Plate II, opposite page 8.)

COMPARISON OF PROPOSED STANDARDS WITH THE REGULATIONS IN
VARIOUS CITIES

This comparison shows that while there is a great variety in method in the various zoning ordinances, there is a surprising agreement in the actual amount of limitation imposed. In our recommendations it is obvious that the rear yard, inner court, and outer court recommendations are somewhat but not much more stringent than the average for a number of municipalities, including New York. The radical departure from precedent is the requirement of side yards in both residence and business

¹ See Appendix X, "Apartment House Study," p. 132.

NOTES: Res. = Residential Building
 Bus. = Business and Office Building
 h = height l = length
 d = depth a = area
 w = width str. = street

TABLE I. BUILDING HEIGHT,

	CONCLUSIONS OF THIS STUDY	NEW YORK CITY ZONING RESOLUTION AND MULTIPLE DWELLINGS LAW	PITTSBURGH, PA., ZONING ORDINANCE	CHICAGO ZONING ORDINANCE
Rear Yards . .	Open Standard d = h Close Standard d = $\frac{1}{2}$ h Max. Res. d = $\frac{1}{2}$ h Max. Bus. d = $\frac{1}{2}$ h d = 20-30 ft. min. in any case	Open Standard d = $\frac{1}{2}$ h Close Standard d = $\frac{1}{2}$ h Max. Res. d = $\frac{1}{2}$ h Max. Bus. d = $\frac{1}{2}$ h d = 10 ft. min. in any case d = 20 ft. min. Open d = 30 ft. min.	Open Res. d = 15% lot depth Max. Res. d = 15% lot depth Max. Bus. No rear yard Res. Close d = 15 ft. max. Res. Open d = 25 ft. max.	
Inner Courts .	Only where = 2 rear yards back to back	Bus. w = $\frac{1}{2}$ h l = 2 w Res. w = $\frac{1}{2}$ h	Bus. w = $\frac{1}{2}$ h w = 10 ft. min. in any case	
Outer Courts .	Open Standard w = $\frac{1}{2}$ h Close Standard w = $\frac{1}{2}$ h Max. Res. Standard w = $\frac{1}{2}$ h Max. Bus. Standard w = $\frac{1}{2}$ h Bus. w = 10 ft. in any case Res. w = 15 ft. min.	Open Standard w = $\frac{1}{2}$ h Close Standard w = $\frac{1}{2}$ h Max. Res. w = $\frac{1}{2}$ h Max. Business w = $\frac{1}{2}$ to $\frac{1}{12}$ h Bus. w = 10 ft. min. in any case Res. w = 8 ft. min.	Open Standard w = $\frac{1}{2}$ h Close Standard w = $\frac{1}{2}$ h w = 10 ft. min. in any case	
Side Yards . .	Side Yards required Start at height = Street width w = same as for Outer Courts Max. w = 40 ft.	Side yards only in F open zone w = same as for Outer Courts	Side Yards only in 1st and 2nd Area District w = $\frac{1}{2}$ lot width 7 ft. min. in any case	
Height and Stepbacks .	Open Standard h = $\frac{1}{2}$ str. w. Stepback d = h Close Standard h = str. w. Stepback d = $\frac{1}{2}$ h Manhattan Standard h = $1\frac{1}{2}$ str. w. Stepback d = $\frac{1}{2}$ h Manhattan Close Standard h = 2 str. w. Stepback = $\frac{1}{2}$ h Wall Street Exception = $2\frac{1}{2}$ str. w. Stepback = $\frac{1}{2}$ h	Open h = str. w. Close h = str. w. Stepback d = $\frac{1}{2}$ h Manhattan h = $1\frac{1}{2}$ str. w. Stepback = $\frac{1}{2}$ h Manhattan Close h = 2 str. w. Stepback = $\frac{1}{2}$ h Wall Street h = $2\frac{1}{2}$ str. w. Stepback = $\frac{1}{2}$ h	Open h = 35 ft. Open h = 45 ft. Close h = 100 ft. Close h = 125 ft. City Center h = 265 ft. No Stepbacks	Open h = 30 ft. Open h = 68 ft. Close h = 132 ft. Close h = 198 ft. City Center h = 264 ft. Stepbacks d = $\frac{1}{2}$ h + $\frac{1}{2}$ h Stepbacks from alleys d = $\frac{1}{2}$ h to $\frac{1}{10}$ h
Towers . . .	Bus. Tower no area limit h = 2 times h on street line d = 50 ft. from street center line d = same as side yard from all lot lines Bus. Towers no height limit a = 25% of lot area d = 50 ft. from street center line d = 40 ft. from all lot lines Towers should set back 3 in. more than 40 ft. from lot lines for each ft. tower exceeds 80 ft. width. Res. Towers no area limit Close Res. Tower h = $1\frac{1}{2}$ str. w. Manhattan Res. Tower h = 2 str. w. Res. Towers d = 50 ft. from street center d = 40 ft. from rear lot line d = 20 ft. from other lot line plus 3 in. for each 1 ft. of two w. over 40 ft.	Bus. Towers no height limit a = 25% of lot area d = 75 ft. from street outer line d = 0 ft. from other lot line where no yards or courts Res. Tower, Area = 20% lot area Close Res. Tower h = 2 str. w. Manhattan Res. Tower h = 3 str. w. Res. Setbacks, Yard and Court require- ments control	Extra h = 2 times widest str. w. d = 20 ft. from street and alleys d = 0 ft. from 1 lot line d = 40 ft. from opp. lot line d = 20 ft. from all others Only in 265 ft. district	No Towers
Lot Areas in Open Resi- dential Zones	In Open or Garden Apartments Total gross area of all floors not exceed area of lot.	Area = 35% of lot area 25% of lot area 18 ft. above curb.	4,000 sq. ft. per family down to 250 sq. ft. per family.	Area = 50% of lot area up to 100%

BULK, AND FORM REGULATIONS

COMPARATIVE STUDY OF TYPICAL EXISTING ORDINANCES WITH RECOMMENDATIONS BY GEORGE B. FORD.

ST. LOUIS ZONING ORDINANCE	CINCINNATI ZONING ORDINANCE	DALLAS ZONING ORDINANCE	SPRINGFIELD, MASS., ZONING ORDINANCE	PROVIDENCE ZONING ORDINANCE
Open d = 15% lot depth Open d = $\frac{1}{2}$ h d = 10% lot depth Max. d = $\frac{1}{2}$ h	Open d = $\frac{1}{2}$ h Close d = $\frac{1}{2}$ h Close Bus. d = $\frac{1}{2}$ h Max. Bus. has no rear yard Open d = 25 ft. min.	Open d = 25 ft. min.	Close h, d = $\frac{1}{2}$ h Max. h, d = $\frac{1}{2}$ h, 10 ft. min. Open d = 30 ft. min.	Open Res. d = 15% lot depth
Open w = $\frac{1}{2}$ h, 6 ft. min. l = 2 times w Max. w = $\frac{1}{2}$ h, 4 ft. min.	Close w = $\frac{1}{2}$ h, 5 ft. min. Max. w = $\frac{1}{2}$ h, 5 ft. min.		Close w = $\frac{1}{2}$ h, 10 ft. min. l = 2 times w Max. w = $\frac{1}{2}$ h, 10 ft. min.	
Open w = $\frac{1}{2}$ h, 5 ft. min. Max. w = $\frac{1}{2}$ h, 4 ft. min.	Close w = $\frac{1}{2}$ h, 4 ft. min. Max. w = $\frac{1}{2}$ h, 4 ft. min.		Width varies with length for each story Max. d = $\frac{1}{2}$ h and 10 ft. min.	
Required only in D Zone Open w = 3 ft. min. and $\frac{1}{2}$ h Max. w = 4 ft. min. and $\frac{1}{2}$ h Open h = 45 ft. Close h = 60 ft. Close h = 80 ft. City Center h = 125 ft. City Center h = 150 ft. Stepback d = h on streets over 70 ft. wide	Required in all Res. Zones Open w = 2 $\frac{1}{2}$ ft. min. and $\frac{1}{2}$ h Max. w = 2 $\frac{1}{2}$ ft. min. and $\frac{1}{2}$ h Open h = 40 ft. Close h = 100 ft. Close h = 141 ft. City Center h = 264 ft. Stepbacks d = $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$ h Res. Stepbacks d = $\frac{1}{2}$ h to $\frac{3}{4}$ h	Open w = 3 ft. min. Open h = 35 ft. and 60 ft. Stepback d = h Close h = 60 ft. and 70 ft. Stepback d = $\frac{1}{2}$ h Max. h = 120 ft. and 200 ft. Stepback d = $\frac{1}{2}$ h	Required Open w = 5 ft. min. Width varies with length for each story Open h = 45 ft. Close h = 60 ft. Stepbacks d = 4 h to 3 h	Required only in residence w = 3 ft. min. and 20% lot w Open h = 50 ft. and 75 ft. Close h = 100 ft. and 125 ft. Stepbacks d = $\frac{1}{2}$ h d = $\frac{1}{3}$ h
a = 2,500 sq. ft. max. Not exceed $\frac{1}{2}$ of street frontage	Bus. Tower a = 25% lot area d = 25 ft. from all lot lines d from street center line = w of tower front	Bus. Tower a = 25% of lot area d = 15 ft. from all lot lines w on street = 60% of frontage	Bus. Tower a = 25% lot area d = 25 ft. from all lot lines d = 50 ft. from street center line	
Area = 50% of lot area 40% above ground story		Area = 6,000 sq. ft. per family 1,200 sq. ft. and 40% lot		Area = 500 to 2,000 sq. ft. per family Percentage of lot occupancy from 60% to 90%

buildings above a height equal to the width of the street. This is compensated for, however, by the much greater leniency in the tower provisions, for in almost all cities where towers are permitted, they are frankly limited to 25 per cent of the lot area, whereas we would place no limit on tower area up to a height equal to twice the height permitted on the street line, provided the towers keep a certain minimum distance away from all street lines, very much as they do in Pittsburgh, Cincinnati, Springfield, and Dallas to-day.

In the more open suburban districts the same principle is recommended: that is, to encourage buildings to go up higher in the air and at the same time to oblige them to cover a much smaller proportion of the lot. It is with this end in view that we would propose in open and garden apartment construction to limit the total gross area of all floors to the area of the lot, which means that there would be no objection to a six-story building, provided it did not cover more than a sixth of the area of the lot and provided it kept a certain minimum distance away from all lot lines.

NEED OF CONTINUING THIS RESEARCH

In this research study we have been most strongly impressed with the vast amount of pertinent data and experience which is waiting to be probed. At most we have only been able to scratch the surface of it in this study. At best this can be only a pathfinder survey. Our conclusions are merely indicative and not decisive, but we believe that they do show strikingly that the pragmatic approach to the subject of the desirable height, bulk, and form of buildings offers immense possibilities of most profitable research. We further believe from what we have been able to glimpse already that a thoroughgoing study of building construction and management data would lead to quite radical improvements in our zoning and building laws, both from the standpoint of the humanitarian and from that of the building owner.

APPENDIX I

TRAFFIC AND BUILDING USE

A great deal has been said concerning the effect of tall buildings on street traffic. Almost without exception the criticism of tall buildings as the principal congestors of streets and sidewalks is based on guess rather than on actual facts. We have been to considerable trouble in trying to find actual facts. These are presented herewith. While they are fragmentary and quite incomplete, they nevertheless seem to prove that skyscraper office or apartment or hotel buildings often do not produce so much traffic congestion, even relative to their ground floor area, as do various much lower buildings of other uses.

For example, in the Philadelphia Traffic Survey Report No. 2 on the Central Business District, published in June, 1929, by the Mitten Management, Inc., Figure 8 on the back of page 22 shows the volume of traffic at selected intersections in the central business district for the maximum hour on a typical week day. Comparing this plate with Figure 12¹ which shows the heights of all the principal buildings in the central business district, it is obvious at a glance that the volume of traffic is quite independent of heights or bulks of buildings. In fact, in almost every case the greatest volume of traffic is along streets where there are few high buildings or few particularly large buildings. The same fact is shown even more conclusively by the traffic flow diagrams in Figure 6 and Figure 7. Figure 15, showing vehicular movements as determined by a check of license numbers, indicates that in the high building district practically all of the vehicular traffic is through-traffic with virtually no traffic stopping at the high buildings. Again, in Figure 14, which shows conflicting movements of vehicles and pedestrians, it is noteworthy that the greatest numbers of pedestrians are on the streets where the buildings are low, rather than where they are higher.

The Report on the Street Traffic Control Problem of the City of Boston, which was prepared in 1928 by the Mayor's Street Traffic Advisory Board, Dr. Miller McClintock, Consultant, would appear to confirm the deductions made from the Philadelphia traffic report.

¹ The references to Figures in this paragraph are to those in the Mitten Management report.

For example, Figure 68 on page 68 of that report presents a traffic-flow diagram. If this is compared with Figure 73 which shows the distribution of buildings according to their heights, we again find that there is no appreciable increase in traffic flow in the streets where the highest buildings are. In fact, almost without exception the greatest traffic flow, according to this diagram, is along streets where there are relatively low buildings.

Again, Figure 101 of that report, which shows the distribution of vehicular speed throughout the city, indicates no noticeable diminution in speed on the streets where the buildings are highest. Speed seems to be determined by the width of roadways and the number of heavily traveled streets close together, rather than by heights of abutting buildings. Moreover, speed is more affected by department stores and high-class shops than it is by the taller office buildings.

Pedestrian traffic in the central business district, according to Figure 196 of the same report, has no peak in the morning arriving hours. The peak at noon is distributed over quite a long period, and the sharp peak at five o'clock at night seems to be influenced more by the stores than it is by the offices.

According to Figure 200 the pedestrian-flow diagram shows strikingly that the amount of pedestrian traffic in the high-building district around School Street and Court Street is less than half as great as it is in the department store, relatively low-building district between West Street and Winter Street.

In a pedestrian traffic count that was made in June, 1923, in Cleveland, it is evident that in the skyscraper office district the pedestrian traffic ranged from 10,000 to 14,000 people a day, whereas a few blocks farther up the same street, Euclid Avenue, where the buildings are mostly department stores with relatively low height, the traffic ranged from 20,000 to 34,000 persons per day.

With regard to department stores, in some tests made recently of revolving doors, it was found that the Marshall Field and Company store in Chicago discharged 1132 people through one door in the ten minutes from 5:00 P.M. to 5:10 P.M. Counts in and out of one door of the Hotel Astor in New York showed 1824 people per hour; in Chicago, research showed 1768 per hour; the Pulitzer Building, New York, showed 1316 per hour; the Commercial Cable Building, New York, 2268 per hour; the Bank of Commerce Building, 1992 per hour. These average about thirty per minute. As people will walk about two hun-

dred feet in a minute and as they can walk about five feet apart, front to back, it would mean that all of these people would not only have time to get away from the building without congestion but they would only occupy three-fourths of one lane in one direction away from the building.

A traffic count which was made at a large department store at the peak hour from 2:30 P.M. to 3:30 P.M. showed a total of 7807 people coming in or out of all six entrances and exits to the building. The peak hour is 17.33 per cent of the total daily traffic from 9:00 A.M. to 6:00 P.M. As the door traffic to one street is about three-fifths of the total for all entrances of the building, it would mean that approximately 4500 people went in or out of the entrance on this street during an hour. This would equal about seventy-five people per minute in both directions, which would mean that this one entrance would monopolize one and three-fourths pedestrian traffic lanes in one direction away from the building.

The Citizens' Street Traffic Committee of the City of New York, Mr. W. W. Arnheim, Chairman, made a special traffic count on May 6, 1929. This count shows that the peak hour traffic in front of department stores tends to run nearly ten times as great as that normally to be found in front of office buildings. The actual store traffic in front of various prominent department stores ranged from 1000 to 4500 pedestrians per hour. This traffic would fill to capacity only one pedestrian lane.

The United States Department of Commerce issued a bulletin in 1926, Domestic Commerce Series No. 9, entitled "Retail Store Problems." It states as follows:

Just what the relationship is between traffic and business, and what the factors are underlying it, have been problematical. Perhaps there has been no question of importance to retail business upon which there has been such a diversity of opinion. The very fact that traffic conditions vary in every retail area, and even every retail-store location, has brought forth an almost equal number of opinions on this subject of far-reaching interest and growing importance.

It is particularly interesting to note in this report that in cities of under 50,000 people the shopping peak is before 11:00 A.M. and after 3:00 P.M., whereas in cities of over 50,000 the peak is between 11:00 A.M. and 3:00 P.M., and this becomes more and more true as a city increases in size, all of which shows that the shopping peak is not superimposed

on the office and loft building peaks which are before 9:00 A.M. and after 5:00 P.M. except for a more distributed peak at the lunch hour.

The traffic flow as counted (see below) was studied, and the day's peak, often occurring in a five- or ten-minute period, was converted to a maximum hourly rate in all cases. This was then computed in relation to 100,000 square feet of net rentable, usable, or "sales" area (as the case might be), or to 1,000,000 cubic feet of building volume.

TRAFFIC IN VARIOUS TYPES AND USES OF BUILDINGS

AN ANALYSIS BY G. B. FORD AND A. B. RANDALL

GENERAL DATA						PEAK HOUR RATE OF TRAFFIC COMPARED TO 100,000 SQUARE FEET USA- BLE AREA	PEAK HOUR RATE OF TRAFFIC COMPARED TO 1,000,000 CUBIC FEET BUILDING BULK
Type of Building	Total Street Frontage	Type of Traffic	Time of Peak Traffic	Season of Test	Remarks		
Department store	1284 ft.	Customers	2 : 00- 3 : 00 P.M.	March	Large popular- price store	5240	1260
Same store	1284 ft.	Employees	8 : 50- 9 : 15 A.M.	March	Large popular- price store	3560	853
Department store	600 ft.	Customers	2 : 00- 3 : 00 P.M.	May	Large exclusive store	623	203
Office building	935 ft.	Departing workers and visitors	5 : 00- 5 : 05 P.M.	June	Varied-use building	974	480.5
Bank	133 ft.	Departing employees	5 : 15- 5 : 20 P.M.	December	Single-use building	1281	759
Office building	—	Departing employees	4 : 45- 4 : 50 P.M.	March	Single-use building	1340	793
Office building	216 ft.	Departing employees	4 : 50- 5 : 00 P.M.	January	Varied-use building	464	253.7
Loft building	300 ft.	Departing employees	5 : 00- 5 : 45 P.M.	—	Single-use building	1860	962
Office building	—	Departing employees	5 : 00- 5 : 05 P.M.	—	Single-use building	Approx. 1310	Approx. 568.5

The results show that the traffic to and from buildings of different types is most markedly different. In general the maximum is to and from the department store, followed by the loft building, then the office building and the banking building. Although these classes of buildings show marked differences, the relative differences within the same classes of buildings are almost as great. Some data were obtained on a typical hotel, but as this was not entrance traffic but only on the elevators, it could not justly be included. Nevertheless, its showing was very much

lower than was that of the other types of structure, when cubic foot volume was considered. (There were no data on the rentable or usable area in the hotel, this being a figure seldom available or used in hotel statistics.)

Although these figures are for but a few buildings, the extreme variation in traffic of buildings even within the same class would indicate the futility of endeavoring to formulate any general rule for use in zoning ordinances that would limit the areas or the bulks of buildings in accordance with their traffic or expected pedestrian traffic.

The pedestrian traffic in elevators in stores depends on the size of the sales area, on whether the store is popular in price or exclusive in type, and on what elevator traffic is provided. The traffic densities observed are as follows, measured in persons per peak hour riding on elevators to points above the ground floor per given number of square feet of sales area. In a popular-priced store the elevators would carry one person per peak hour for every twenty-five square feet of sales area above the ground story, while in an exclusive type of store it would be one person per forty square feet of sales area. In bargain basements the elevators, escalators, or stairs would carry down one person per hour for every seven square feet of sales area.

In a store building the sales area tends to become from 80 per cent to 90 per cent of the gross area in central congested districts where the "remote delivery" system and warehouses, etc., are the present tendency, since the centrally located store space is far more profitably employed in the selling of goods, and the store building is designed with the absolute minimum of utilities. If a building covers 16,000 square feet on ten floors, 80 per cent of the sales area would equal 128,000 square feet. According to the figures given above, this would mean a total traffic, except on the ground floor, of 6430 people. The ground floor traffic would probably be as much again, according to observation, which would mean a total of 12,860 persons per hour. This would equal only a little over 200 people per minute, which at most would not absorb more than two and one-half traffic lanes in both directions, distributed over all the sides of the building. If the building faced on four streets it would only mean about one-third of a lane in both directions on each street.

The counts show that the store employees' traffic peak coincides with that of loft buildings and not with the peak of the users of the stores. The loft building peak is a little earlier than the office peak and tends

TABLE II

THREE-MINUTE COUNT OF PEOPLE LEAVING AND ENTERING A NEW YORK STORE, SATURDAY, DECEMBER 14, 1929, BETWEEN 3:00 P.M. AND 4:00 P.M. (ALL FIGURES REDUCED TO A PER-MINUTE BASIS.)

REVOLVING DOORS ¹						SWING DOORS							GRAND TOTAL	AVERAGE PER DOOR PER MINUTE
	1	2	3	4	Total	1	2	3	4	5	6	Total		
A	34	34			68	35	30	26	24	33	32	180	68	34
B						40	42					82	180	30
C	40	44	41	41	166	40	42					82	248	41.3
D	20	38	40	36	134	40	41	40	40			161	295	36.9
E ²						24	17	29	15	24		109	109	21.8
F	18	18			36	41	50					91	127	31.8
G						23	13	14	25			75	75	18.8
H	55	36			91	60	52					112	203	50.8
Totals	14 doors				495	25 doors						810	1305	

NOTE— There are no standards for measuring door capacities. Those who observed conditions at the entrances are of the opinion that when the rate per door per minute gets to be much above 30, the situation becomes uncomfortable.

TWO-HOUR COUNT OF PEOPLE ENTERING A NEW YORK STORE BY PRINCIPAL ENTRANCES, NOVEMBER 17, 1928

	A	B	C	D	E	F	G	H	TOTAL	PER CENT OF EACH 10- MINUTE PERIOD TO GRAND TOTAL
2:00-2:10	250	491	683	1247	263	162	153	591	3840	8.20
2:10-2:20	250	715	1088	1752	241	141	104	425	4716	10.08
2:20-2:30	163	782	753	1375	296	111	123	508	4111	8.79
2:30-2:40	226	825	746	1398	222	130	132	499	4178	8.94
2:40-2:50	106	662	1059	1748	203	152	89	421	4440	9.47
2:50-3:00	108	768	1239	1245	199	131	120	467	4277	9.14
3:00-3:10	153	616	967	1382	240	90	87	389	3924	8.39
3:10-3:20	165	524	787	1564	202	146	91	477	3956	8.45
3:20-3:30	143	674	592	1087	227	83	93	368	3267	6.99
3:30-3:40	139	606	808	1201	125	118	88	482	3567	7.63
3:40-3:50	153	578	775	1174	284	126	98	283	3471	7.41
3:50-4:00	146	476	555	1264	119	111	72	301	3044	6.51
	2002	7717	10052	16437	2621	1501	1250	5211	46791	100.00
Per cent of total	4.26	16.49	21.47	35.16	5.60	3.21	2.68	11.13	100.	

¹ One revolving door is considered as the equivalent of two swing doors, since it allows uninterrupted passage in both directions at the same time.

² Count made at outside doors.

to overlap it. However, we find office buildings, loft buildings, and stores are usually in different districts so that the main conflict of stores, if any, would tend to be more with loft buildings than it would be with office buildings. The peak hours in the various types of buildings are substantially as follows:

TYPE OF BUILDING	A.M.	NOON	P.M.
Office	8 : 30 to 9 : 00	12 : 30 to 1 : 30	5 : 00 to 5 : 30
Loft Buildings	7 : 30 to 8 : 30	12 : 00 to 1 : 00	distributed
Store Customers . . .	— 10 : 00	1 : 00 to 2 : 00	little after 4 : 00
Store Employees . . .	8 : 40 to 8 : 45	use store cafeterias	5 : 40 to 6 : 00

In any event, the store employees' traffic would be much less than the customers' traffic and relatively unimportant at best. However, it is interesting to note that in a large department store in New York during the Christmas rush there were nearly 14,000 employees.

Table II shows clearly how the crowd of pedestrians passed in and out of a particularly busy department store. It is interesting to note that from the central doorway *C*, 248 people moved in and out every minute at the rate of 41.3 people per door. This means that if the average person walks 200 feet per minute and people can walk as close as five feet apart with an average distance of two feet apart, side by side, this one doorway will absorb the sidewalk capacity in both directions of three complete sidewalk lanes, or in other words six feet of sidewalk width. By the same method of calculation, the various doors *D*, *E*, *F*, *G*, and *H* will absorb a total fully as large as the sidewalk capacity of the street on which they front.

Table II also shows that this capacity use of sidewalk space has been shown to continue from 2 : 00 P.M. to 3 : 20 P.M., and from then until 4 : 00 P.M. it drops about 20 per cent. This will be added to the other pedestrian traffic on the street, but it should be considered that present-day merchants consider pedestrian traffic volume on the abutting street an asset, not a liability, and would believe themselves seriously harmed if plans were made to disperse or eliminate it. There is doubtless a point where such congestion ceases to be an asset to the merchant, but we do not yet know what this point is.

It is true that in a few instances the sidewalk used by skyscraper office buildings approaches similar figures, but whereas in the case of the office buildings this maximum use is confined to very short peak-load

periods, in the case of the department stores it is distributed more or less uniformly throughout the day.

The total daily traffic in and out of a large 38-story office building was counted at nearly 125,000 people. This means that two and a half people per square foot of ground area per day enter or leave the building, or it means that one person per day enters or leaves the building for every ten square feet of total rentable area. Of the 125,000 users of the building only 92,000 are carried on the elevators, or less than 75 per cent. Nearly 25 per cent use the building only as a thoroughfare instead of using the bordering sidewalks. The peak-load traffic in and out of all doors is 176 people per minute. This peak was approached only at one o'clock and at five o'clock. Over half of this traffic is through one particular entrance. Therefore it can be said that 90 people enter and 90 people leave, or a total of 180 people use this particular entrance each minute during the short peak-load period. This would absorb the capacity of two and a quarter sidewalk traffic lanes or a total width of about four and a half feet of sidewalk. It is interesting to compare this with the much larger and vastly longer sidewalk peak load of the department store mentioned on page 43.

Recent pedestrian traffic-counts in a number of leading American cities show that the total number entering department stores varies from 6000 daily, in a small outlying store, up to 60,000 just before Christmas for a large metropolitan store. In fact, the same store will reach a peak of 80,000 or better on the Saturday before Christmas.

These pedestrian counts also show that the percentage of the total number of people who use the sidewalk next to the store and actually enter will run as low as 15 per cent in a busy center of a large city and will run as high as 60 per cent in a good-sized store on the edge of the shopping district. It was also found that the percentage of women on the abutting sidewalk who would actually enter the store would sometimes run as high as 89 per cent or 90 per cent. Another interesting figure, as far as passing stores is concerned, is the percentage of a metropolitan population that passes the store. This runs as low as 2 per cent of the population in the case of a poor site in Boston, and 2.7 per cent of the population in a good location in New York, but the figure can run as high as 25 per cent of the total population at a particularly excellent business corner.

In San Francisco, September, 1929, a count of pedestrian traffic was made in and out of seventy-nine office buildings and twenty-five retail

stores. The four largest stores had a total daily traffic of almost three times the total of the four largest office buildings. The rush-hour and noon-hour traffic was found for each 1000 square feet of office space for the seventy-nine buildings, and for each 1000 square feet of gross sales space for six large department stores. The following tabulation gives a comparison of this store and office building pedestrian traffic :

	OFFICE BUILDING	STORE
Average daily traffic per 1000 sq. ft. of floor space	74.8	160.3
Rush hour traffic per 1000 sq. ft. of floor space	7.9	15.9
Noon hour traffic per 1000 sq. ft. of floor space	11.38	29.4

High office buildings permit a large number of individual tenants or business firms who have frequent occasion to transact business with each other to be housed in a very limited area, thereby greatly facilitating personal contact, which is a valuable factor in the conduct of modern business. This personal contact would probably be more difficult and perhaps frequently impossible if the same floor area were spread in low buildings over a very large district. The National Association of Building Owners and Managers, in the 1926 Report of their Committee on Height Limitation, made the following statement.

The experience of just two cities [Pittsburgh, Detroit] might be cited to show that tall buildings do not of necessity cause traffic congestion. In the city of Pittsburgh there is a block on Fourth Avenue in the financial district which is solidly built up with tall buildings, most of them 150 feet or over in height. These buildings, due to a shortage of office space, have been 100 per cent rented for the past several years, so that there has been ample opportunity to observe conditions as they would be at their maximum population per rentable square foot. Two blocks north, there is on Fifth Avenue a block of space located parallel to Fourth Avenue on which there is only one high building, the balance of the space being occupied by theaters, department stores, chain stores and restaurants. The sidewalk traffic on Fifth Avenue is almost ten times as great as that of Fourth Avenue and the street traffic is so great that parking has never been allowed, and for a time it was thought that some means would have to be devised to remove the street car traffic. Fourth Avenue, on the other hand, had, until about eighteen months ago, parking regulations allowing machines to park for one hour, and even now, with parking regulations strin-

gently enforced in the entire downtown district and all parking abolished on principal streets, there are never any serious tie-ups on Fourth Avenue and no congestion. Conditions, even from 4 : 30 to 5 : 30 P.M., when the occupants of office buildings are leaving for home, are infinitely better than Fifth Avenue at any hour of the day. It is a fact which may be easily proven that a two- or three-story department store or theater will attract during the business hours more people than a twenty-story office building, regardless of its type of tenants.

Accurate figures obtained in Detroit show that one department store had a traffic for one day of 114,727 persons and another had a traffic of 88,920 persons. A large office building, 312 feet in height, had a traffic from 7 A.M. to 6 P.M. of 10,260 persons and the population of the building is only 3039 persons. The number of persons leaving one department store between 5 and 6 P.M. was 16,575 and in another store the number was 13,275. The largest office building shows on one day during the same hours a total of 1624 persons and on another day a total of 1476 persons.

Figures recently published show that the traffic at the express stops of the Interborough Rapid Transit at the Times Square, Grand Central, and Pennsylvania stations averages between 40,000 and 50,000 per day. The increase during this last year at the Times Square and Pennsylvania stations has been relatively slight, thanks to only a small amount of new building in their neighborhoods. The traffic at the Grand Central Station has increased between 10 per cent and 15 per cent, which roughly corresponds to the increase in rentable area in the same district during the year. It is obviously and admittedly possible to increase transit facilities with the demand, though not necessarily at a rate of cost which the demand would directly pay for. If, however, the convenience and the efficiency of functioning of those who use the office buildings, and so indirectly of the whole community, are sufficiently enhanced by concentration in the Forty-second Street district or in the Wall Street district, then it might well be good business to provide the additional transit facilities as needed. It is generally admitted that from the standpoint of the operation of a rapid transit line, concentration pays much better than dispersion.

As far as pedestrian access from the skyscraper to the subway is concerned, what is actually happening at the Grand Central Station indicates the obvious solution of the problem: that is to say, each of the tall new skyscrapers has its own underground, broad, brightly lighted passageway

direct from the building to the express station. Each of these underground passageways takes a noticeable amount of pedestrian traffic from the streets. In other words, in practice the largest bulk buildings are providing their own extension to the sidewalk capacity at their own expense.

Another aspect of the relation of traffic to large bulk buildings is whether the skyscraper contributes materially to the increase in street accidents. The following tabulation, based on the accident statistics of a city of a million people, shows conclusively that the greater number of fatalities occur from accidents in the outlying districts and not in the congested areas.

ANALYSIS OF ACCIDENTS ACCORDING TO PRECINCTS, YEAR 1927¹

PRE-CINCT	FATAL	SERIOUS	SLIGHT	REMARKS
1	9	30	250	Area in which central business district is located
2	10	41	309	Contiguous to central business district
3	18	68	482	Foreign and colored population — automobile accessories manufacturing
4	15	71	389	Residential — some manufacturing
5	24	73	341	Residential, principally foreign manufacturing
6	18	54	198	Steel plants, foreign population
7	11	59	205	Residential
8	13	62	347	Residential, foreign population
9	19	85	264	Residential — manufacturing
10	10	54	200	Residential — manufacturing
11	15	69	308	Sub Center, high grade residential — parks
12	11	29	218	High grade residential
13	10	64	355	Foreign population — manufacturing
14	16	46	245	Good residential — some manufacturing
15	6	16	114	Residential — manufacturing
16	13	47	173	Residential, mixed
17	6	26	79	Residential, mixed
Total	224	894	4477	

¹ From Report of Committee on Height Limitation, National Association of Building Owners and Managers, Proceedings for 1928.

The following tabulation shows more specifically the relation of these traffic accidents to the type of district in which each took place. It is particularly interesting to note that less than half of one per cent occur in the office building district.

ANALYSIS OF TRAFFIC ACCIDENTS (224 FATALITIES)¹

LOCATION OF ACCIDENT	NUMBER	PER CENT OF TOTAL
Office building district	1	.45
Street car terminals	3	1.39
Market district	2	.89
Civic center	1	.45
Cheap retail district	2	.89
Downtown apartment district	5	2.34
Thoroughfares radiating from city	5	2.34
Foreign and colored districts	83	37.0
Manufacturing districts	21	9.3
Residential	101	45.0
Total	224	100.0

¹ From Report of Committee on Height Limitation, National Association of Building Owners and Managers, Proceedings for 1928.

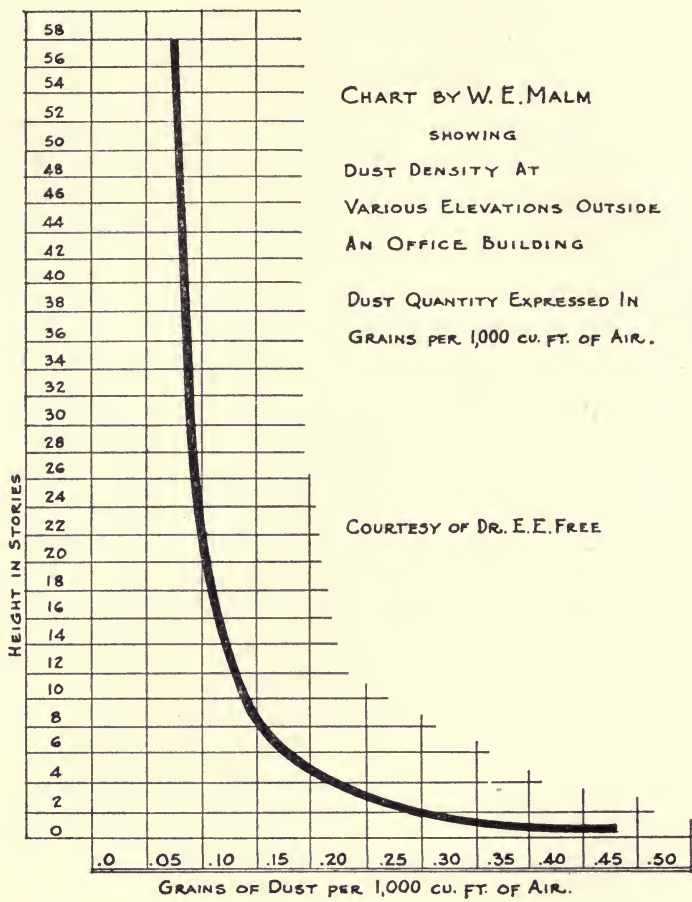
The traffic commissioner of another large city states that less than 5 per cent of all traffic accidents occur in the business district and that the greatest density of accidents is found in neighborhoods populated by low-wage earners. Obviously, part of this low rate in business districts is due to the better traffic supervision there.

APPENDIX II

SAFETY AND EGRESS

The National Association of Building Owners and Managers, in the 1927 Report of its Committee on Height Limitation, makes the categorical statement that there has never been a panic or cause for one in any tall building. Such is vastly more likely to occur and has occurred in various instances in the large retail stores or theaters. While conflagrations have damaged a few tall buildings, notably in San Francisco and in Baltimore, there was not the slightest difficulty in getting the occupants out. In fact, in the case of the Burlington Building in Chicago, the fireproof skyscraper building actually acted as a barrier to stop the spread of the conflagration. A fire in the top of the Equitable Building in New York did no great damage. The same is true of the fire on the sixteenth floor of the City National Bank Building in Omaha. Even in the very oldest skyscrapers, built before modern construction and fire prevention methods were demanded, no fire in a skyscraper has proved to be dangerous. For example, the fire which occurred on the fifth floor of the old thirty-two story Park Row Building in New York quickly burned out a large suite of offices filled with highly inflammable material and through the open windows spread into the two floors directly above, but the writer's own office four floors above was entirely undamaged, thanks merely to the closing of the windows.

The figures of the National Board of Fire Underwriters demonstrate that the high office buildings very rarely have fires. The Building Owners Federation of Mutual Fire Insurance Companies, in its ninth annual report covering fire insurance experience on office buildings of forty-four cities, shows that in at least two cities there have been no losses at all in skyscraper office buildings. This statement, however, refers to buildings which were members of their Mutual Association. These were in general somewhat better managed than the average and naturally were selected "risks." More generally representative is the fact that during the past decade the country-wide payment of fire losses by the Federation for any one year has never exceeded 10 per cent of each dollar of premium received.



GRAPH-10

Mr. A. T. North ¹ makes the following statement :

We do not expect that in case of fire every one will rush to the stair-way and descend to the street. What is much more likely to happen is that people will use the stairs to reach a point, say, two stories below the point of origin of the fire, where they can be safe at least for the time being and may then leave the building in a more leisurely manner. It is on this account that the horizontal and vertical subdivisions of a building are of primary importance in the case of very high structures.

Obviously there is a limit to the number of flights of stairs which the normal person can descend without distress. Three athletic men were nearly "all in" when they walked down fifty stories in the Woolworth Building. In the fire in the eleven-story Hotel Marguery one woman died from a heart attack induced by descending ten flights of stairs. The fire itself, however, was actually confined to the basement. Except in the Hotel Marguery fire the elevators have proved adequate as a means of egress under panic conditions. In that case through mistake in judgment or faulty construction the elevator shaft was allowed to become full of smoke and the current for the elevators and lights was shut off. In most skyscraper buildings this contingency is provided for and the same trouble could not occur.

In general, it is a reasonable assumption that the occupants of tall structures are sufficiently intelligent to understand the inherent qualities of fire-resistive buildings to the extent that they will be unlikely to be dangerously panic-stricken under any reasonably predictable circumstances of fire, smoke, gas, or earthquake shock.

As to safety from wind damage, also, it is an interesting fact that in the recent Cuban hurricane, where the wind blew one hundred miles per hour, killing some five hundred persons and destroying over a million dollars' worth of property, no serious damage was done to any modern steel frame or reinforced concrete structures in its path. What is more interesting still is that ordinary low buildings, even those with masonry walls, failed quite extensively.

Tests made in New York and other cities show that with the wind-bracing required under the New York and other building codes, there is not only no danger but there is no appreciable sway or trepidation in tall buildings due to gales of wind.

¹ "Tall Building Egress," in *The Architectural Forum*, Feb. 1930.

APPENDIX III

DUST, GAS, AND NOISE

DUST AND GAS

The National Air Filter Company of Chicago reports that Mr. G. T. Palmer of New York has made measurements of dust concentration at the Woolworth Building where he obtained the following results :

At the street level there are $\frac{48}{100}$ of a grain of dust per thousand cubic feet of air. At the 10th story there are $\frac{13}{100}$ grains of dust per thousand cubic feet of air. At the 58th story, $\frac{74}{1000}$ of one grain of dust per thousand cubic feet of air.¹

This means that there is about one-fourth as much dust in the air at the tenth story as there is at the street level, and about one-seventh as much at the fifty-eighth story as there is at the street level. The interesting part of these figures is that the decrease in the amount of dust in the air from the street level to the tenth floor is nearly seven times as much as the decrease in dust from the tenth floor to the fifty-eighth. In other words, the air does not get very much purer above the tenth floor than it is at that level; or again, there is no particular advantage in going above the tenth floor to get purer air. It is fair to state that above the tenth or twelfth floor even in the center of Manhattan, the air begins to compare favorably with country air. Graph No. 10, which was prepared for the 1928 Proceedings of the National Association of Building Owners and Managers, shows by a curve the effects just discussed.

In a letter written June 3, 1930, by the United States Public Health Service, the accompanying table of the dust content in New York City air² is appended.

It will be noted that the dust content in the streets is twice as great below Fourteenth Street as it is above Forty-second Street. The only way this can be explained is by the fact that the streets are a little narrower below Fourteenth, with a great deal of trucking and perhaps less

¹ National Association of Building Owners and Managers, Proceedings for 1928.

² From experiments during the period from July, 1927, to May, 1928.

individual cleaning of building and sidewalks. It is also to be noted that dust content in New York above Forty-second Street is four times as great as it is in the residential portion of Brooklyn, and twenty times as great as country air during a rainstorm. Air inside of offices and apartment houses is just about the same as that in the street.

SUMMARY OF COUNTS OF DUST CONTENT OF AIR

NO. OF SAMPLES	SAMPLING PLACE	AVERAGE DUST ¹ COUNT IN MILLIONS OF PARTICLES PER CUBIC FOOT OF AIR
25	Subway and railway station air	3.9
18	Subway train air	3.0
26	Office air in downtown New York	2.8
45	New York City air in downtown section: south of 14th St., East & West	2.7
15	New York City air between 42nd and 72nd Sts., from Hudson River to Broadway	1.3
9	New York City air between 154th and 187th Sts., from Hudson River to Amsterdam Avenue	1.3
6	New Haven air in business section	0.6
9	New York City air between 72nd and 110th Sts., from Hudson River to Central Park West	0.4
18	Brooklyn residential section air	0.4
6	Dwelling in New Haven	0.4
4	Unused laboratory in New Haven	0.2
4	Country air during rainstorm	0.05
185 Total		

With regard to carbon monoxide gas, as emitted by automobiles, the following report¹ was made recently before the National Conference Board of Sanitation with regard to conditions in the streets of New York:

In the matter of carbon-monoxide, a number of readings were taken, particularly in some of the city buses which we felt were improperly ventilated. We also made a considerable survey of carbon-monoxide on the city streets. The recorder which we used was the Bureau of Mines' recorder, using hoolamite as the material, and that would read five parts in ten thousand, whereas symptoms of poisoning in the human body may be detected when no more than one part in

¹ "Carbon Monoxide Conditions in the Streets of New York." Report by Dr. H. H. Sheldon before the National Conference Board of Sanitation, October 30, 1929.

one hundred thousand is present in the air breathed, and five parts in ten thousand [or .05 per cent] was decidedly dangerous.

At 42nd Street and Fifth Avenue at 9:00 A.M. August 29th, we found approximately .05 per cent on the sidewalks, on the edge of the sidewalk and near the cars. It was particularly large when the cars were starting. The weather at that time was light, westerly breeze, and the humidity was high. I might say that for the most part each one of these readings represents a very large number of determinations on that particular day. In one particular instance you might happen to get a little cloud of carbon-monoxide, and the next instance the air might be free.

At the Grand Central Terminal Taxi Concourse we had a reading of .05-.07 per cent at the station entrance about one minute out of every five.

At the Pennsylvania Terminal Taxi Concourse approximately .05 per cent was obtained.

In the Holland Tunnel, in which it is claimed the air is clear, we found that to be the case.

At Broadway and Wall Street we found that the reading was only obtained when cars were beginning to start into motion at the changing of the signal.

In Brooklyn at Borough Hall, Court Street side, we had a dangerous reading at least once every fifteen minutes.

At Atlantic and Fourth Avenues the reading was somewhat higher than in most places. It was obtained about one minute in every seven.

At Flatbush Avenue Extension and Fulton Street, there again we had a dangerous reading once in every ten minutes, and at Prospect Park Plaza no reading at all.

The upshot of this investigation is that at the street level, where traffic is thickest, the accumulation of carbon monoxide gas is often dangerous to health. On the other hand, it is a well-known fact that this gas being heavier than air does not rise, and where it is dissipated by the breeze it is so attenuated by the time it arrives at upper window levels as to have no appreciable effect. If anything, the presence of carbon monoxide gas in the streets would seem to be an argument in favor of increasing the height of buildings so as to remove people as far as possible from its effects.

Smoke, obviously, has a direct effect on the amount of dust in the air, on the lightness of the exterior of buildings, and thus on the reflecting value of opposite walls. Furthermore, the greater the amount of smoke in the air, the less the penetration of sunlight and light to the street. Incidentally, it injures parks and trees and lawns and disfigures buildings. By obscuring the sunlight it adds to the cost of artificial lighting. By

discoloring and injuring buildings it leaves a financial burden upon their owners and managers. Finally, excess smoke means wasted fuel.

Dr. Shirley W. Wynne, President of the Board of Health of New York City, gave recently through the National Welfare Conference Board the following statement :

Sunlight is a necessity. Yet even in parts of the city where the sun should shine freely, as along Riverside Drive, a smoke pall settles because of the industrial developments across the river. And by some curious perversity of city growth the best parts of the city in many instances are preempted by industrial development. While we realize the inability to get rid of these developments, we cannot allow them to pollute the air.

Smoke abatement is a matter of education of the individual. The Health Department is carrying out a vigorous educational campaign among owners of buildings and boats, managers of factories, etc. It appeals to these owners by means of a straight business proposition. It seeks to show them that by making the city a more healthful place they will make their pockets fatter. It is attacking smoke from buildings within the limits of the city and smoke from craft on the surrounding rivers and in the bay. Through the generous coöperation of officials in New Jersey it is trying to eliminate the smoke from factories across the Hudson.

Already the work is bearing fruit. At the beginning of last Winter 80 per cent of the smoke produced was preventable. Today 70 per cent of this preventable smoke on Manhattan has been done away with and 50 per cent of the smoke nuisance on the rivers.

* * * *

Inspectors will keep a lookout over the city from the tops of tall buildings. They will hold powerful field glasses. Whenever they detect smoke they will telephone to headquarters. Engineers of smoking buildings will be notified that they are violating the law. If the smoke does not stop within a reasonable time they will be haled to court. The time is at hand when smoke from a chimney will mark the owner as an enemy of public health and also as singularly ignorant of the progress of modern scientific knowledge.

What is true of New York City is true of most other American cities. Smoke as a factor in determining the maximum height and bulk of buildings is rapidly disappearing and there is good reason to hope that within a relatively short time it will become negligible.

With regard to ventilation and windows and their effect on the height and bulk of buildings, there are little data available. In a bulletin of the American Meteorological Society of June-July, 1923, Professor

Charles F. Brooks of Clark University presented a paper entitled "Local Climates of Worcester, Massachusetts, as a Factor in City Zoning." His conclusions were as follows: Parks should occupy the exposed hilltops, where people can get the purest air and the greatest stimulation from the winds and sun. The best residential conditions should be found adjoining the parks on the southeast and south slopes toward the prevailing summer breezes and above the usual reach of the cold air accumulations of the valley bottoms. The cold damp of the valley bottoms rarely penetrates more than a third of the way up the hills. The adjacent southwest and southeast slopes of these hills are the next best residential locations.

A letter from Mr. D. R. Morris, Meteorologist of the New York Meteorological Observatory, says:

We would say that normal prevailing winds over New York City are from the northwest for all months excepting July and August when they are from the southwest. We have sixty-one years of record made in Central Park of the prevailing winds. No study has been made by the Observatory on the effects of winds upon air currents in enclosed or other type of courts or on the effects of hills on wind and air currents.

With modern methods of construction there is obviously little need of trying to avoid a northwest exposure on account of any fear of cold winter winds. On the other hand, realizing that the prevailing summer breeze in most places in this country is usually from the southwest at the time when most windows are open and when circulation of air is most needed, an orientation of streets, of buildings and of windows, and also of courts and yards, that will allow the southwest breeze most easily to penetrate into the greatest number of rooms is obviously desirable. Other things being equal, a southwest orientation of buildings, courts, and yards should be determining in the design and layout of buildings as well as streets. Fortunately, the north-and-south streets of the city make an angle of only about 27° or 28° with the southwest, so that the avenues serve as flushes for the prevailing summer breeze. Fortunately, too, this is within 17° of the orientation from which the most beneficial effect of sunlight and light can be had.

As to the effect of the circulation of air and of breezes in courts and over the walls of buildings, it is true that many studies of air currents have been made in connection with the manufacture of airplanes, but there seems to be a consensus of opinion, borne out by general observation, that even an enclosed court is rarely stagnant; for the moment windows facing upon a court are opened, a cross draft is created which

pulls through the rooms and up the court as a chimney. It is true that the tenement house law provides for a three- by seven-foot air intake to every enclosed court. In practice this has proved a most useful device and effective in assuring a circulation of air even in the deadest summer day. In general, the circulation of air is of minor moment in comparison with other factors affecting the height and bulk of buildings. Even the swirling of dust through the city canyons has been proved by experiment to show very little effect actually harmful to health in the upper stories of buildings.

The following is a statement by Dr. Max C. Starkloff, Health Commissioner of St. Louis and nationally known medical authority :

1. *Streets.* Finely divided particles of dust consisting principally of inorganic matter in varying quantities are present on the surface of city streets. This is thrown into the air which we breathe with the wind, and is irritating to the mucous membrane of the respiratory tract, influencing to a non-determined degree the incidence of acute respiratory diseases. It is not to be understood in this case, however, that the dust carries the infecting agents that persons harbor, in their upper respiratory tract. The germs cause influenza, pneumonia and common colds, and the dust through its irritating action affords the avenue of the infection.

Street dust is contaminated with the bacillus of tuberculosis by the secretions of the lungs of consumptives who expectorate upon the streets and sidewalks. This germ will withstand drying and will survive over a considerable period when protected from sunlight. It is difficult, if not impossible, to say to what extent tuberculosis is spread through the medium of street dust.

I can see no relation of the streets and cerebrospinal meningitis, eye strain and damage to eyes. Streets heavily congested with automobile traffic are apt to have an atmosphere sufficiently charged with carbon-monoxide gas as to cause headache, fatigue and to affect working efficiency, depending upon the factor of time during which persons are exposed to this atmosphere.

2. *Street Cars.* Acute respiratory infections are spread through the medium of discharge from the nose and mouth of infected persons. Necessarily, heavy street car traffic with crowded cars bringing people in close contact promotes the spread of these diseases. In street cars people are brought in sufficiently close contact to permit the spread of tuberculosis, diphtheria and cerebrospinal meningitis by means of what is known as droplet infection. This is by infected persons coughing, sneezing, and in conversation frequently throwing out invisible droplets of infected secretions. It is to be understood, however, that exhaled air from man or animal, diseased or otherwise,

contains no germ life. Street cars are apt to be a factor in eye strain to no others than those operating the car. Improper ventilation, overheating, are apt to excite headache and interfere with working efficiency.

3. *Department Stores and Theaters.* Sunlight is one of our most effective natural agents for the destruction of disease germs, and research in recent years has shown that the ultra-violet rays of the sun have a stimulating effect upon the animal tissue, and favorably influence health in an unmeasured degree. Most disease germs cannot survive the process of drying, and an abundance of fresh air will tend to hasten this process. It is common knowledge that plenty of fresh air is essential to our physical well-being, and that improperly ventilated places of habitation depress the spirits, cause physical discomfort, hasten fatigue and interfere with mental and physical efficiency.

NOISE

Dr. E. E. Free, consulting research engineer of New York, has used a device which he calls an Audiometer to measure sound scientifically. While he has taken many measurements of sound at different points in New York, he has always felt that there is no great practical value attached to taking such measurements at different altitudes and locations. His tests would seem to indicate that noise is practically uniform from the ground story to the third story; that it starts to decrease somewhat at the fourth or fifth story, and disappears very largely on the upper floors of high buildings. Of course this varies markedly with the individual case and in particular with the height and distance away of buildings across the street. If the opposite building contains large glass area or if it is broken up with vertical columns or deep window reveals, the noise is noticeably less than where the opposite wall is flat, solid masonry.

Mr. John S. Parkinson, engineer of the acoustical section of Johns-Manville Corporation, has prepared a curve showing the relative intensity of street noises on the Fourth Avenue side of the New York Life Building. (This curve is not available for reproduction at this time, or at least until released by the Acoustical Society.) The New York Life Building has a setback at the fifth floor, another at the fourteenth, and another at the twenty-sixth. The buildings across Fourth Avenue are four, eight, twelve, thirteen, and seventeen stories high.

According to the tests, measurements of sound intensity at the street level indicate sixty-six decibels. (For example, twelve and a half decibels represent the comparative difference between a subway roar and the noise of the same train in an open cut.) The intensity of sound increases

progressively to the second setback level of the New York Life Building, — that is the fourteenth floor, — where an intensity of sound of 67.5 is reached. Above this level it falls to 60 decibels because the insurance building is by that time above the roofs of opposite buildings. The intensity then remains relatively constant, being about 63 decibels at the twenty-sixth floor. The drop from 67.5 to 60 decibels at the fourteenth floor represents a very noticeable diminution in intensity of noise.

To quote from a letter from Mr. John S. Parkinson :

It is a commonly observed fact among employers and business men that excessive noise either within the room or from the street seriously hampers the efficiency, accuracy, health and good temper of the workers affected. For a long time no specific data as to the amount of this loss were available, but recently psychological laboratories have succeeded in proving quantitatively that such a loss exists.

With regard to actual noise levels, the New York Noise Survey showed that the average minimum noise level encountered in the City streets was 48 decibels above threshold, and the maximum 83 decibels. In the interior of offices and business spaces the level varied from 34 decibels minimum to 74 decibels maximum. Without going into any very great detail as to what these levels mean, I think you can tell by comparison with the familiar levels of street noises how high the levels in office interiors must be.

Our tests on different levels above the street brought out one or two rather interesting facts. Apparently, as long as the surrounding buildings are as high or higher than the level at which the test is made, the height above the street makes very little difference. In other words, these "canyons" confine the sound and carry it upward to such an extent that you cannot get away from it until you get above the surrounding buildings. Once the height of the surrounding buildings is passed, the noise changes in character and proves to be composed of the general roar of the City rather than of any specific street noise. We continued our tests as high as the 35th story, and were not able to get above this general curtain of noise which appears to be present. The quietest floors measured were those opposite the set-backs of the buildings, which apparently acted somewhat as baffles to reflect the sound away from the windows.

The most interesting deduction from these studies is that the setbacks in the upper levels of buildings produce zones or backwaters of quiet that are fairly appreciable. These may be anywhere from one to three or four stories in height.

It is also obvious that the wider the street — in other words, the greater the distance away of the opposite building due to street width

or to setbacks — the less the reverberation of noise. It is another rather interesting fact that the Acoustical Society of America has brought out in its discussions that the noises in an office reduce the efficiency of the employees by as much as 10 per cent. On the other hand, it has often been maintained in their discussion that the source of noise in houses and offices is within rather than outside the building. Incidentally, the corner of Canal Street and Broadway is one of the noisiest places in the city, despite the fact that it is surrounded by low buildings.

The following information was obtained from the preliminary report of the Committee on Noise Measurement and Survey of the Department of Health of the City of New York, released on March 25, 1930.¹

At most stations, the noise level in decibels was observed about four times per minute, over a period of about ten minutes, that is, during several traffic cycles. The arithmetical average of these instantaneous levels is termed the Average Noise Level for the station. The following table ² shows the extremes of the average levels found, together with fourteen intermediate levels arranged in order of average levels. The stations are selected to exemplify a large variety of locations and conditions. For each station, the maxima and minima are shown, as well as the average level.

LOCATION	NOISE LEVEL IN DECIBELS		
	Minimum	Average	Maximum
New York University Campus	43	45.6	52
Mosholu Parkway near Bainbridge Ave. . .	48	52	68
President St., Brooklyn	44	57.5	73
Central Park, South End of Mall	51	60	70
Broadway at 116th Street	50	64.5	78
Borough Hall, Brooklyn	59	67	74
Fifth Avenue at 42nd Street	60	67.5	74
Broadway at 42nd Street	60	68.5	77
Fifth Avenue near 56th Street	63	69	78
Broadway at Canal Street	63	72	86
Herald Square, 6th Ave. & 34th Street . .	64	73.5	90
Manhattan Bridge, near Center	68	74	78
Park Ave. at 71st Street	68	74.5	81
Holland Tunnel, West-bound Entrance . .	68	76	83
Bowery and Canal St. under elevated . .	73	79	85
Grand Concourse, near 196th Street . . .	71	80	96

¹The final report of this Committee has since been issued in printed form under the title, "City Noise."

²This table is taken from page 149 of "City Noise," the final report of the Noise Abatement Commission.

As would be expected, in general those locations having the greatest volume of traffic have also the greatest noise level.

To determine the relation between the average noise level at a location and the number of vehicles passing per minute, stations were selected having approximately homogeneous traffic. Ten stations were thus chosen for which passenger automobiles constituted 90 per cent or more of the total traffic, with no street cars or elevated trains. It was found that the average noise level increases by three decibels when the number of vehicles per minute is doubled. Stated otherwise, the average noise intensity is directly proportional to the number of vehicles per minute. This relation holds over a wide range of traffic volumes; but when the number of vehicles per minute is increased beyond fifty, the rate of increase of the noise falls off, due, in part at least, to the increasing street width involved.

The results indicate that for a traffic volume of thirty vehicles per minute, consisting chiefly of passenger automobiles and motor trucks, and involving few street cars and no elevated trains, an increase of 20 in the percentage of motor trucks causes an increase of about 3.5 decibels in the average noise level.

Based upon the previous results, it should in general be possible to predict quantitatively, for any particular place, the effect upon the average noise level which will result from a known change in the volume or the composition of the traffic.

As regards the effect upon the noise level of the local geography, the heights of surrounding buildings, distribution, etc., the data of the survey have not yet been completely studied. It seems, however, that for noise measured as in the survey, with the truck carrying the microphone parked in the street very near the traffic, the geography is much less significant than the volume and composition of the traffic.

It is interesting to note that where measurements were made at the same spot on different days, but at the same time of day, the variation was slight, not more than 1 per cent in any case.

The degree of annoyance would seem to depend largely on the character of the noise itself, as to whether it is continuous or intermittent and whether or not noises are commonly regarded as quite unnecessary, such as the squeaking of automobile brakes or the screeching and drop at the rail joints of street car wheels or whether they are, on the other hand, noises that are regarded as necessary, such as police whistles.

APPENDIX IV

LIGHT AND SUNLIGHT

Light and sunlight, according to the consensus of qualified opinion, constitute the most important factor in determining the desirable maximum height and bulk of buildings. Many attempts have been made to reduce the minimum desirable standards of light and sunlight to a quantitative basis. The British Law of Ancient Lights is the earliest attempt to assure a minimum standard of light to the ground story windows of all buildings. According to a study entitled "Light," which was made by Mr. Lawrence Veiller for the National Conference on City Planning in 1929,¹ the Law of Ancient Lights dates back to the reign of Richard Coeur de Lion in the year 1189. In 1832 the practice of centuries was embodied in a statute law entitled "The Prescription Act." Under this act it is provided that if a window in a building has uninterruptedly enjoyed the access of light for a period of twenty years, that right becomes permanent. If a neighboring building is raised so as to interfere with a light right, the man whose light is cut off can sue the owner of the new building for damages and, in some cases, has actually succeeded in having the new building cut down in height to the point where the light right would be protected. The Law of Ancient Lights is based entirely on the theory that any man can control his neighbor. It means that if a man has happened to have a particularly low building on his land for at least twenty years, any one of his neighbors can prevent him from ever erecting any higher building; or, if he does erect a two-story building instead of the former one-story building, his neighbors can all hold him up for damages. However justified this may be under British law, it is inconceivable that this principle could stand the tests of the American courts.

The erection of two very tall buildings in London — Queen Anne's Mansions and Hankey's Folly — led to the enactment in 1894 of a building by-law imposing an absolute limitation on height of buildings erected

¹ "Planning Problems for Town, City and Region," p. 124. Papers and Discussions of May, 1929, meeting of National Conference on City Planning.

in the future in London. The standard set at the time was a height limit of eighty feet, with two stories additional in the roof, at the discretion of the local authorities. This is the law to-day.

A similar law exists in Paris, known as the Law of Servitudes. According to this law a building may go up as high as the width of the street it faces upon, plus a stated additional height of from five to twenty feet, which differs in different parts of the city, and then the building can go still higher within the one, two, or even three mansard stories. This means that the average maximum height is six to seven stories, with an absolute maximum of nine stories. The height limitations in German, Austrian, and other continental cities are all based on one or the other of these two principles.

In this connection it is interesting to see how the London height limitation law corresponds to that of New York. Mr. Francis Swales, architect, in a memorandum to Mr. Thomas Adams, the Director of the Regional Plan of New York and Its Environs, under date of May 21, 1930, says that in winter the sun in New York is about eleven degrees higher than it is in London. In other words, on the shortest day in winter the minimum angle of direct sun's rays in London is 15° and in New York $25\frac{1}{2}^{\circ}$. He goes on to say that in a London street fifty feet wide, with a building at the maximum height of eighty feet, the ground story receives the fourth reflection of the direct light. The same light value in New York would be received over a building 144 feet high.

In London a building may be erected eighty feet high on a street forty feet wide, or twice the street width. Thus the governing angle of height in relation to street width is $62\frac{1}{2}^{\circ}$. For the same light value the governing angle in New York would be more than $67\frac{1}{2}^{\circ}$, or two and a half times the width of the street. This corresponds to the maximum provision of the New York Zoning Ordinance, where the two-and-a-half-times zones — as they are called — are confined to the small financial district at the lower end of Manhattan. In other words, under the British law, buildings can go as high anywhere in London in proportion to the intensity of light at the ground story, as they can in the maximum district in New York, which comprises only a fraction of one per cent of the total area of the city. For the shortest days of the year, the maximum light protection by the London law is therefore the same as the minimum protection given by the present New York zoning law. Mr. Swales goes on to say that, in addition, the advantage as to amount of light at the street level is still further with New York because the walls there are

much lighter colored and reflect much more light than those in London which are dark colored and grimy and therefore absorb a great deal of light.

Furthermore, a comparison of photometric tests as between the two cities shows that better light is probably obtained in New York on the fourth reflection than in London on the third reflection, or probably even the second, due to much better average atmospheric conditions in New York. Still another advantage in favor of New York is the fact that the average building there is apt to have a much larger glass surface than do corresponding buildings in London. In other words, the present zoning law of New York, and in fact of most American cities, is more stringent than is the case in London in the amount of light which it assures to ground story windows.

The height limitations in Paris would seem to average in the neighborhood of one and a half times the street width. This corresponds to the one-and-a-half-times height districts now in existence in nearly three-fourths of the area in Manhattan and in similar sections of other larger cities, although it is true that in most of the area of the other four boroughs of New York, and, in fact, in most of the larger cities in the United States, the actual height limit under zoning is less than that in Paris and much less than that in London.

Mr. Percy J. Waldram, a leading English authority on light standards, in a paper read before the International Congress on Illumination in 1928,¹ entitled "Daylight and Public Health," said in part :

The real crux will be the minimum distance to which penetration into buildings should be secured by legislation.

Pending a more complete inquiry by an International Commission, he recommended the following tentative standards :

(a) That positions from which no sky at all is visible at table height are inadequately lit for ordinary purposes, such as continued clerical work, and

(b) That it is undesirable that rooms should be constructed, or used for habitancy, or for clerical or other ordinary work over long periods, unless they have at least some sky visible from table height over some reasonable portion of their area.

The law as laid down by the courts on the question of what constitutes adequate light is thus expressed elsewhere by Mr. Waldram :

¹ Proceedings, p. 477.

The fundamental basis of the standard of inadequacy which has been adopted in the English courts in connexion with Ancient Light disputes for some years, is that light should be sufficient in moderately dull weather, such as a wet summer's day, when the sky may be assumed to be of a light even grey, equivalent to an illumination of 500 foot-candles from a complete unobstructed hemisphere, whether the situation be Birmingham, Bognor, or Biarritz.

The first tenement house law in the United States, which was enacted for New York City in 1867, regulated the space between front and rear buildings on the same lot by saying that there should be ten feet clear between them in the case of a one-story building, fifteen feet for two-story, twenty feet for three-story, and twenty-five feet for buildings higher than that. It was the first recognition of the principle that the size of the open space should be dependent upon the height of the abutting walls.

In 1885 a statute was enacted for New York City, providing that the height of future buildings for more than one family should be regulated in proportion to the width of the street, not to exceed seventy feet on streets of sixty feet in width or less and not to exceed eighty feet in height on streets of greater width.

With the enactment of the New York Tenement House Law in 1901, definite recognition was given to the broad principle that "the size of all open spaces left for the purpose of providing light and ventilation shall in every case be regulated by the height of the building." This principle has since been copied throughout the country.

With the passage of the zoning resolution of the City of New York in July, 1916, this same principle was extended to all classes of buildings in every part of the city, and it has since been followed in almost all of the larger cities and in most of the smaller cities of the country.

Mr. Lawrence Veiller very justly says of these laws:¹

They were not rule of thumb methods. They were pragmatic attempts to establish a law of physics. They were in no essential respects different from the methods applied to-day. Instead, however, of basing one's conclusions on astronomical or mathematical calculations made in an office, the simpler and more direct method was employed of observing the amount of light and shadow in existing buildings of various heights and with various sized open spaces. Though we did not mention such terms as "azimuth," "hyperbolic quadrilaterals," "sines" or "cosines," "Angström units" or "millimicrons," we were

¹ See footnote on p. 62.

just as scientific in fact as if we had employed all of the jargon of the present-day scientist.

The first attempt to make a scientific quantitative study of minimum sunlight and light standards was made by M. A. Augustin Rey, a well-known architect of Paris, who about twenty-five years ago published in the "Presse Médicale" a series of articles in which he worked out mathematically how buildings would have to be oriented and how far apart they would have to be in proportion to their height in order to assure one hour of sunlight to every window at noon on the shortest day of the year. M. Rey admitted that this was a purely empirical standard though determined after long discussion of the subject with leading medical authorities on tuberculosis and other diseases affected by sunlight. Using these principles as a basis he made a number of designs for model tenements in Paris and in fact in other cities. In 1910 he gave a series of lectures on the subject of these studies in the larger eastern cities of the United States, at which the writer acted as interpreter. As far as is known, this is the first discussion of a scientific quantitative approach to the assurance of proper light and sunlight to buildings.

In 1912 a book entitled "Orientation of Buildings or Planning for Sunlight" was published by a Boston architect, Mr. William Atkinson. He developed a technique for determining the amount of light and shadow as a result of experimentation with a series of "sun boxes" which he built for that purpose. He reached the conclusion that cities should not be planned with east and west streets because the surface of such streets would receive no sunlight at all during six months of the year and the buildings on the south side would be in perpetual shadow during the same period. This independent study corroborates the much more elaborately worked out conclusions of M. Rey, as published several years earlier.

The first attempt in this country to determine a scientific quantitative basis for assuring light and sunlight in buildings was made by the New York Heights of Buildings Commission in 1913 and was followed up by its successor, the Commission on Building Districts and Restrictions. The writer, who was in charge of the technical work of both commissions, assembled the researches of M. Rey and Mr. Atkinson and delegated Mr. Herbert S. Swan and Mr. George W. Tuttle to study their application to American, and in particular to New York, conditions. Our findings were published in the final report of the Commission on Building Districts and Restrictions in June, 1916, and later Mr. Swan and Mr. Tuttle elaborated their studies and published them in the *American City Mag-*

azine in September, 1917, under the title, "Planning Sunlight Cities," and also in two articles¹ in *The Architectural Forum* in June and November, 1918. The results of the studies are presented in a series of tables, graphs, and formulae which are obviously far too complicated to write into a zoning ordinance, building code, or dwellings law.

It is a matter of record that in developing a zoning ordinance for New York we spent a great deal of time trying to see if there might not be some way of interpreting these quantitative standards in the terms of a zoning ordinance that might be readily applied by the average architect, builder, or realtor. The upshot was that we found there were so many other complicating features that it would be impracticable to try to use a definite quantitative minimum standard of light and sunlight in the zoning ordinance; that the best we could do, as a practical proposition, would be to try to approximate roughly a desirable standard by some much simpler and broader method of control. We also found that if we wished to assure the enactment of a zoning ordinance we would have to make concessions to existing conditions, approaching our optimum as nearly as we could but letting down from it where so forced to do in order to assure the passage of the law. In fact, like most laws, the zoning law of the City of New York is a compromise, as are those of all municipalities.

A little later studies were made by Mr. Arthur A. Shurtleff, landscape architect and city planner, of Boston, and by Mr. H. L. Seymour, town planner, of Canada. Both these studies presented devices for determining the shadow cast by an obstructing object under varying conditions.

By far and away the most scientific approach to this problem was made by Mr. Wayne D. Heydecker and Mr. Ernest P. Goodrich for the Regional Plan of New York and Its Environs and published in Volume VII of the Regional Survey in a monograph entitled "Sunlight and Daylight for Urban Areas." These studies have been carried further and the conclusions applied to typical cases by Mr. Heydecker in a paper, also entitled "Sunlight and Daylight for Urban Areas," which he prepared for the American City Planning Institute at its meeting of April 5, 1930. The conclusions have also been stated in Volume VI of the Regional Survey. In final Plan Volume II, Mr. Thomas Adams, as the General Director of the Regional Survey, has used the findings of Mr. Heydecker and Mr. Goodrich as a point of departure in drawing conclusions as to desirable limits on height and bulk of buildings in New York.

¹ "Sunlight Engineering in City Planning and Housing."

In substance Mr. Heydecker and Mr. Goodrich have consulted all the available authorities on the relation between sunlight and air and health. They have then discussed how land can be planned to obtain an adequate sunlight standard, using the method first laid down by M. Rey as a point of departure. However, they have carried their studies further than they have ever been carried before and have developed mathematical curves and formulae for securing a certain minimum amount of direct sunlight or direct sky light to every window in a great many typical kinds of buildings on a great variety of typical locations. They have discussed in particular sky light as a partial substitute for or supplement to sunlight, making a great many photometric tests. The most interesting conclusion from their studies was: "Direct sunlight at noon intensity is approximately three times as intense as the average sky shine at the thirty-degree horizon." Their studies included a determination of desirable sizes of windows in relation to the rooms which they served and their location in the outer wall. Their corroborative summary statements with regard to sunlight are as follows: ¹

1. Sunlight is a beneficial agent in the prevention and cure of rickets.
2. Sunlight is a beneficial agent in the prevention and cure of certain common forms of tuberculosis.
3. Sunlight is a beneficial agent in the prevention of certain other diseases through the destruction of harmful disease germs and through the general strengthening of the powers of resistance.
4. Sunlight is a helpful agent in facilitating ventilation by causing gentle movements of the air due to the unequal heating by the sun of different sides of houses reached by it.
5. To summarize, sunlight is an important aid in the prevention and cure of certain specific diseases, it is one of the most effective destroyers of harmful bacteria, it is the heat of the sun rather than its light which is responsible for most of the ill-effects of over-exposure, and through its direct and indirect influences it is an important aid in developing human vitality and building bodies which can fight active disease and disease tendencies effectively.

Thus having shown that there is a vital relation between sunshine and health, their study assumes that in the interest of public health and public welfare the minimum reasonable amount of sunshine which should be available for every room in dwelling houses is one-half hour of noon

¹ See Regional Survey of New York and Its Environs, Vol. VII: Neighborhood and Community Planning, p. 199.

intensity or its equivalent on the shortest day of the year; it demonstrates that in order to secure this minimum requirement north-and-south streets should not deviate more than 10° from the true north-and-south line, and a better arrangement of lots and of houses on the land should be employed, suggestions for such arrangement being described in detail; it states that, in cases where some rooms cannot secure the sunlight standard, daylight can be used as a substitute under certain conditions; and that these conditions include the enlargement of window areas by at least fifty per cent and the spacing of buildings at such distances that for every window which does not receive direct sunlight at least one per cent of the half dome of the sky shall be visible from any part of the room. This means, among other things, that sky shine might be substituted for sunshine in rooms with windows facing in a general northerly direction only by increasing the amount of land required, and that the amount of land required will thus be increased beyond the typical 40×100 -foot plot in residence districts if dwellings or other interfering buildings are made more than twenty-five feet high.

The chief difference between the studies of Mr. Heydecker and Mr. Goodrich on one side and M. Rey, Mr. Atkinson, and others on the other side, is that M. Rey assumed from his consultations with medical men that the heliothermic rays of the sun were the important ones in assuring good health, whereas Mr. Heydecker and Mr. Goodrich gathered from the more recent medical authorities whom they consulted that the ultra-violet rays were of far more importance to health than the heliothermic rays. M. Rey found that the heliothermic rays were most effective at a deviation of 19° to the east of north. As north-and-south streets of New York City make an angle of between 22° and 23° with the north, the heliothermic axis is very nearly parallel with the north-and-south streets and at almost right angles to the east-and-west streets. In the same way, the greatest heliothermic effect would be not at noon but between one and two o'clock in the afternoon.

Mr. Heydecker and Mr. Goodrich, on the other hand, found that the ultra-violet rays, in combination with the other beneficial effects of sunlight, average their greatest germicidal effectiveness at noon or very close to noon, and also found that this value began to drop noticeably when windows faced away from the south. They found, too, that the greatest ultra-violet ray effect upon health occurred not when the sunshine was most intense but about the middle of the forenoon or the middle of the afternoon, which led them to conclude that windows facing east or west

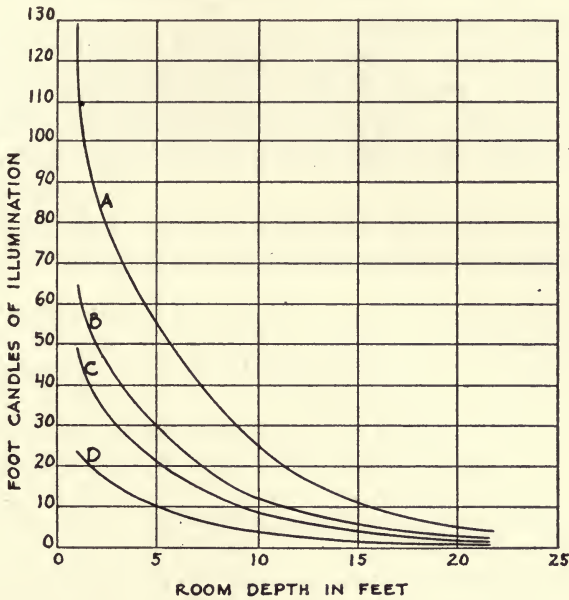
would enjoy a large portion of the beneficial effect of sunlight and light in its health-giving qualities. This would mean that the north-and-south street is the most desirable type of street, but they found that if the street varied more than 10° from north and south, one side of the street gained noticeably at the expense of the other.

The latest book on this general subject of light and sunlight as applied to buildings is entitled "Easements of Light," by John Swarbrick, published in England.¹ The object of the book is to try to find mathematical formulae for computing compensation under the English Law of Ancient Lights. The book discusses various methods, such as the method of angles which is based on the principle that there should be a clear view of the sky at an angle up 45° from the sill of any window. He also discusses photometric principles and the law of inverse squares. He then discusses the cosine light law and Professor Kerr's law. The book shows in detail how to project the actual amount of sky visible from any window and the relative amount of illumination received within any room.

A study has recently been made by Mr. William E. Malm, building manager, of Cleveland, in collaboration with Mr. Ward Harrison of the National Lamp Works. A copy of their chart is given herewith in Graph No. 11, in which they show by a series of four curves the relation of the foot-candles of illumination within a room to the depth of the room in feet, assuming that the window has an excellent exposure. The curves all show that light has already lost half of its intensity five feet back from the window and has lost four-fifths of its intensity ten feet back.

With regard to these questions of light and sunlight that we have reviewed above, we have recently asked the opinion of various medical and public health authorities. Virtually without exception they have told us that it is impossible to isolate sunlight and light from among the many factors that contribute to good health and well-being. They feel therefore that it is difficult to put the determination of minimum open spaces for health about buildings on a quantitative basis, depending as it does on more or less empirical minimum standards of sunlight and light. Typical of these talks is one with Dr. Louis I. Dublin, Chief Statistician of the Metropolitan Life Insurance Company. Dr. Dublin stated that thousands of factors influence health, including heredity, background of health, sleep, play, and in fact many factors in addition to light and air. In other words, he felt that it would be unreasonable to put any

¹ "Easements of Light: Modern Methods of Computing Compensation." London, B. T. Batsford, 1930.



QUALITY OF WINDOW EXPOSURE

- A- JUNE DAY-CLEAR.
- B- " " -CLOUDY.
- C- DECEMBER DAY-CLEAR.
- D- " " -CLOUDY.

GRAPH-II

determination of practical minimum light standards on a quantitative basis.

Therefore, as before when we were drafting the building zone resolution for New York City, we have again come to the same conclusion: that it is impossible to determine any practicable minimum sunlight and light standards that we can use quantitatively in determining the maximum desirable height of buildings and the minimum size of yards and courts and other open spaces.

The great American insurance companies and the school authorities, where they have a public health department, have been asked about light, air, and health in office and school buildings. Every one reached so far contends that this problem has not as yet been thoroughly investigated.

Dr. C. E. A. Winslow, President of the American Public Health Association, makes the following positive statement.

It would be impossible to produce statistical data to support either side of this controversy, for the simple reason that statistics are not kept in a way so that they might be broken down to furnish this information. Furthermore, there are so many factors entering into the situation that it would be next to impossible to compile statistics of this nature. Germany has furnished statistics showing infant mortality lower in the upper floors of tenements than in the lower floors, but this proves nothing so far as commercial buildings are concerned.¹

Of various agencies consulted to gather information, it is felt worth while to quote the following ¹ from Mr. Henry Bruere, Third Vice President of the Metropolitan Life Insurance Company:

We have never made any statistical compilation or study to determine whether or not there is anything particularly unhealthy about modern office buildings. We have always felt that a building which is properly lighted, heated and ventilated is a satisfactory place for the performance of clerical work and there is no health menace that we know of.

F. L. Grosvenor, Medical Director, The Travelers Insurance Company, says: ¹

So far as I have been aware we haven't any statistical evidence which would have a bearing upon the premises referred to in your letter.

¹ National Association of Building Owners and Managers, Report of Committee on Height Limitation, 1926.

I can consequently only say in a general way that the nearer to the ideal a building conforms in relation to ventilation, atmospheric humidification, proper lighting and heating and freedom from congestion the more favorably affected will be the health and efficiency of its occupants.

Dr. J. Allen Patton, Medical Director, The Prudential Insurance Company, gave as his opinion : ¹

I find that we have no tabulation of records showing the effect upon health of our policy-holders in tall buildings. It is possible that the National Housing Association may have some such information, but I am inclined to think it will be based more upon the opinions of individuals than upon any definite data or collection of cases that they might have obtained.

Eugene L. Fisk, Medical Director, Life Extension Institute, Inc., says : ¹

We have no worked-out statistics at the present time which would be of any value for the purpose that you desire.

Haven Emerson, M.D., of the College of Physicians and Surgeons, Columbia University, states :

There is no unequivocal evidence of the damage to life and health due solely to the limitations of light and air movements by tall buildings.

Briefly, the prevalence of the communicable diseases bears no direct relation to the height of buildings except as they contribute to the congestion and increase of close personal contact in streets and street cars.

As far as the items harmful to health are concerned, these are in no way necessarily due to any of the conditions created by tall buildings. All of these disabilities may and do occur abundantly where there are no tall buildings, and their occurrence can be readily prevented by suitable environment, light, air, and working conditions even where skyscrapers prevail.

The effects of department stores, theaters and office buildings upon the two groups of conditions you give are no different from such as occur anywhere among groups of people who fail to observe the laws of personal hygiene."

¹ National Association of Building Owners and Managers, Report of Committee on Height Limitation, 1926.

APPENDIX V

THE MOST PROFITABLE BUILDING ON VARYING LAND VALUES

Much thought and attention has been given in recent studies to the size of building which will show the greatest return on the investment for varying land values.

Messrs. Clark and Kingston in their recent book "The Skyscraper" have discussed this subject at length, considering land values between \$100 per square foot and \$600 per square foot. Their analysis considers only a plot substantially 200 feet by 405 feet. In this study, however, the same rental rate is used for not only the ground floor commercial space, but also for the entire office space under all the above-named ranges of land value. This assumption results in an understatement of the skyscraper since the rental rates, either for the ground floor alone or for the general office space, will vary as the land value varies, although not in a direct proportion (see Graphs Nos. 12 and 13). The analysis in Mr. Clark's book would, therefore, tend to show much lower returns on the total investment for land values above \$200 per square foot, and perhaps the reverse for land values below this point.

Following Mr. Clark's analysis to a logical conclusion, one would become convinced that it would be most unprofitable to build any structures on land of a value of more than \$200 per square foot. This conclusion is believed again to underestimate the potential earnings of the skyscraper, since if land should have any very high value, as, for instance, \$500 a square foot, it would only have such a value by reason of the fact that a return on the investment commensurate with such a land value is possible.

The study of the probable "maximum size" of building, constructed so that it will show the maximum return on the investment, is a most difficult matter for the following reasons :

1. Variations in the size and shape of plot
2. Effect of elevators and building utilities
3. Variations in rental rates
4. Variation in building cost per cubic foot
5. Variation in time of construction

It is obvious that the size and shape of the plot might greatly influence all the other conditions of any building erected. A building may economically be much higher on a very large plot than on a small area.

What may be termed the "core of utilities," — namely, elevators, stairways, vents, ducts, elevator lobbies, toilets, and necessary building corridors, — diminish the net rental area developed in large structures. The higher the structure the greater is the tendency of decrease in net area when this is compared to the cubic feet of building constructed.

The average or composite rental rate of a building tends to increase with increases in size of building. However, this tendency to increase is likely to stop as soon as a point is reached in a building where the outlook and view are practically uninterrupted by any other buildings. Furthermore, the premium paid by many tenants for space in the summits of our lofty structures is liable to decrease when a large amount of this very high space is produced.

The time of construction of a building of given size might be some period such as twelve months. However, the doubling of the size of this building would not necessarily mean that double the time of construction would be required. Study of representative progress charts, either laid out in advance or from construction records of a particular building, reveals that at the initial period of work, progress tends to be slower than during the major portion of the time. Further, that at the end of any given job or operation there is a decreasing rate of accomplishment due to the general finishing-up of the work. It may, therefore, be deduced that a building of double the size of any building for which construction records are known, may be reasonably expected to take less than double the period of time required for the first building.

The effect of certain published schedules of large buildings is always open to the question of whether all operations are included within the dates shown. Frequently the time of demolition of an old structure occupying a site is not recorded. In other cases the excavation and foundation work is not included, while in others the period of time elapsed is only counted until the installation of the few tenants in particularly favorable locations.

It is obvious that the true time of construction, upon which the cost of holding the land idle and the interest rates must be reckoned, should closely approximate the full time including the demolition of the old structure on through until such time as the building is available for the tenants with whom leases have been signed.

In addition to this an allowance should be made as a definite and legitimate cost for the time required to bring the building occupancy to such a point that the rentals cover and meet taxes, operating costs, and interest on the mortgages and the like, but without profit to the owners.

In an endeavor to formulate an approximate estimate of the building of such a size that it will afford the maximum return on the investment, as based upon the best available information on present-day rental rates, cost per cubic foot, operating cost, mortgage interest, financing costs or discounts, and tax rates, etc., and granting in advance that all these factors are in a state of flux, the following possibilities of variations must be granted at the outset.

1. The plot area must be of such a size that a sufficient core of utilities may be provided without undue loss in the general efficiency of the building. Such a condition would be rarely met in most urban plots, and the maximum size of building deduced from analysis based upon this assumption will be considerably larger in most cases than is economically practical. (This is the reason for the trend toward large plots.)

2. Although the average rental would be somewhat higher in the maximum building than would be found in most buildings existing on present-day plots, and although this would tend to increase the possibilities of return on the investment, this factor must be neglected in the following analysis because it is quite probable that a building of this maximum size would either have initial vacancy cases larger than those set up in the analysis, or the rental rates would have to be reduced somewhat below normal in order to attract tenants.

The cubic foot cost of a very large and tall building would, of necessity, be greater than that of smaller buildings. On the basis of the first assumption, — namely, that the plot should be of sufficient size to accommodate an efficient building, — it would be obvious that the tower of this very large building would closely approximate the conditions of a large building set on a smaller plot without any setbacks whatever. To counteract somewhat the effect of increasing cost due to size alone, there will be another factor tending toward compensation: namely, the effect of economy through what might be termed wholesale or mass production.

The possibilities of decreasingly proportionate construction time in the large building should tend to lessen the effect of carrying charges during construction and the resultant total capital costs, thus tending to increase the probable rate of return on the investment.

To reiterate these factors it may be seen that, although the increased influence of space required for elevators and other utilities might tend to diminish possible returns, this factor is somewhat compensated for by probable lower carrying charges during construction. Furthermore, although the cubic-foot cost of the large building may be somewhat increased, this factor may be considered as somewhat compensated for by a probable increase in rental rates.

To exactly what degree these factors and possibilities of variation would actually cancel in any given project, even on a very large site, is problematical and would depend upon conditions. However, an analysis or approximate estimate has been made with these possibilities of variation acknowledged at the outset. Considering the general elements which go to make up a financial set-up of an office building, as outlined in the article "The Minimum Building for Varying Land Values"¹ by Keast and Randall, the following conclusions have been reached as to the maximum building that would be economic to construct on varying land values between the limits of \$100 and \$500 per square foot, as shown in Graph No. 2. This graph shows the total rentable area required per square foot of plot for the "minimum building" and for the "maximum building."

In the first case this "minimum building" is one of such a size that it will bring in a return of 10 per cent upon the equity investment, in accordance with the general custom of financing through a bond issue and in which the bond issue covers substantially 80 per cent of the total project appraisal.

It might be very properly observed here that the operative builder of to-day is unlikely to go into a project upon which he is expected to put up over 10 per cent in cash. A study of the usual method of financing shows that first mortgages, as arranged by a Trust Company, seldom exceed about 60 per cent of the cost of the building and the value of the land. Such a percentage based upon only these two major factors of a financial set-up of a building actually become only about 50 per cent to 55 per cent of the total project costs. The typical first mortgage granted by an institution engaged in the business of bond issues seldom exceeds 66 per cent on the appraised valuation. However, this appraised valuation is usually considerably higher than that granted by a Trust Company, and usually includes the land at a greater value than its actual cost. Additional mortgages usually bring the total loan to about 80 per cent of the appraisal value.

¹ *The Architectural Record*, Apr. 1930.

Land is usually bought by a successful operator somewhat in advance of its better and higher use. The difference between the price actually paid for this land and its value under the conditions of its new use, represents the operator's or promoter's profit.

In the second case, for the "maximum building" the total rentable area per square foot of plot is that area required to afford the maximum potential returns on the investment. In other words, if a smaller rentable area per square foot of plot is developed the income may be smaller in proportion to the total investment, and if a larger rentable area per square foot of plot is developed it will be found that the carrying charges during construction, etc., so increase the capital costs that, although the gross return in actual dollars may be greater, yet this return compared to the required investment shows a lesser rate of earnings.

Graph No. 2 also shows in curve form the ratio between building cost and land value for both the "minimum" and the "maximum" buildings, as previously defined. It is interesting to note that the earnings on the total investment vary between $8\frac{1}{4}$ per cent and $8\frac{1}{2}$ per cent, and that this would represent — under the conditions assumed — a return of between 14 per cent and 15 per cent upon the equity investment.

Although this analysis tends to show that the possibilities of equity earnings for even the "maximum building" on any given land value are less than a 15 per cent rate, it should be remembered that this rate of return will actually be much higher and even in many cases more than double this amount when it is considered that the land may be purchased at a given price and a project successfully developed thereon which may warrant a much greater land value than indicated by its purchase price.

TABLE III

CALCULATION FOR THE MAXIMUM BUILDING TO THE POINT OF DIMINISHING RETURNS, BASED ON CARRYING AND OTHER CHARGES, EXCLUSIVE OF THE EFFECT OF ELEVATORS. THE PLOT MUST BE OF SUFFICIENT SIZE TO PERMIT EFFICIENT ELEVATORS. BASED ON LAND AT \$200 PER SQUARE FOOT.

	GENERAL									
	<i>Calculation per square foot of Plot</i>									
	\$200 1.80	\$200 1.85	\$200 1.925	\$200 2.0	\$200 2.25	\$200 2.4	\$200 2.5	\$200 2.75	\$200 3.0	
A. Land Value per square foot of plot area.										
B. Ratio of Building Cost to Land Value	360	370	385	400	450	480	500	550	600	
C. Building Cost, including Builder's Profit and Architect's fee, excluding carrying charges during construction	.68	.68	.68	.68	.68	.68	.68	.68	.68	
D. Same as C, per cubic foot	529.5	544.5	566.7	588	662	706	735.0	809.5	882	
E. Building Cubage or Volume	18.25	18.25	18.25	18.25	18.25	18.25	18.25	18.25	18.25	
F. Ratio between Cubage and the net rentable area developed	29.0	29.8	31.0	32.2	36.22	38.68	40.30	44.3	48.35	
G. Total net rentable (or usable) area developed	28.3	29.1	30.3	31.5	35.52	37.98	39.60	43.6	47.65	
H. Same as G, excluding Ground floor area (usually about 0.7 square foot per square foot of plot)										
J. Construction rate, in cubic feet per square foot of plot per month from start of demolition to completion including sufficient number of rentals	22	22	22	22	22	22	22	22	22	
K. Construction time on the above basis in years	2.00	2.06	2.143	2.22	2.505	2.67	2.78	3.06	3.34	
N. Ground floor rental rate (average) per square foot per year of net rentable or usable area	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	
O. Office floor rental rate on the above basis	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	3.86	

CAPITAL COSTS

	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200
A. Land Value per square foot of plot area										
C. Building Cost, including Builder's Profit and Architect's fee, excluding carrying charges during construction	360	370	385	400	450	480	500	550	600	
U _a . Taxes during construction (<i>K</i> years) on the Land	7.70	7.94	8.27	8.17	9.65	10.28	10.70	11.79	12.87	
U _b . Same as U _a on the Building	6.93	7.34	7.95	8.17	10.85	12.34	13.40	16.20	19.30	
V. Gross interest on the funds for the above period	106.10	111.95	120.60	128.70	161.80	182.70	198.30	240.0	285.5	
W. Interest Credit on funds for the above period	14.38	15.26	16.62	17.88	23.20	26.58	29.12	35.9	43.4	
X. Net interest cost on the funds for the above period	91.72	96.69	103.98	110.82	138.60	156.12	169.18	204.1	242.1	
Y. Financing cost of fees or discounts on the funds	51.25	52.45	54.24	55.85	62.27	66.05	68.85	75.70	82.50	
Z. Initial Vacancy Cost (loss of rental during the initial period before building reaches normal occupancy)	35.28	36.20	37.65	39.00	43.65	46.50	48.47	53.0	56.50	
S. Total capital costs of Capitalization (sum of the following: A, C, U _a , U _b , X, Y, and Z)	752.88	770.62	797.09	822.01	915.02	971.29	1010.6	1110.79	1213.27	

INCOME

	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200
P. Ground floor income	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	
Q. Office floor income	109.20	112.30	117.0	121.6	137.0	146.60	153.0	168.40	180.0	
R. Total of <i>P</i> and <i>Q</i> if building were 100% occupied	117.60	120.70	125.4	130.0	145.40	155.00	161.4	176.80	188.4	
T. Same as <i>R</i> if 90% occupied	105.95	108.60	113.0	117.0	131.0	139.50	145.25	159.00	169.7	

EXPENSES

	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200
Operating	19.72	20.25	21.10	21.90	24.63	26.30	27.41	30.17	32.88	
Taxes	10.79	10.98	11.28	11.55	12.51	13.09	13.46	14.46	15.90	
Insurance	0.43	0.44	0.46	0.48	0.54	0.58	0.60	0.66	0.72	
Amortization	13.84	14.30	14.94	15.56	17.90	19.28	20.27	22.80	25.35	
Total General	44.78	45.97	47.78	49.49	55.58	59.25	61.76	68.09	74.35	
Interest, Earnings, and Tax Refunds	61.17	62.63	65.22	67.51	75.42	80.25	83.49	90.91	95.35	
Percentage on Total Investment	8.125	8.135	8.18	8.215	8.245	8.26	8.25	8.17	7.855	

TABLE IV

CALCULATION FOR THE MAXIMUM BUILDING TO THE POINT OF DIMINISHING RETURNS, BASED ON CARRYING AND OTHER CHARGES, EXCLUSIVE OF THE EFFECT OF ELEVATORS. THE PLOT MUST BE OF SUFFICIENT SIZE TO PERMIT EFFICIENT ELEVATORS. BASED ON LAND AT \$50 PER SQUARE FOOT.

	GENERAL				
	<i>Calculation per square foot of Plot</i>				
	(1)	(2)	(3)	(4)	(5)
	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50
A. Land Value per square foot of plot area	3.8	4.0	4.15	4.3	4.7
B. Ratio of Building Cost to Land Value					
C. Building Cost, including Builder's Profit and Architect's fee, excluding carrying charges during construction	190	200	207.8	215	235
D. Same as C, per cubic foot	.45	.45	.45	.45	.45
E. Building Cubage or Volume	422	444.4	461	477.5	522.2
F. Ratio between Cubage and the net rentable area developed	17.90	17.90	17.90	17.90	17.90
G. Total net rentable (or usable) area developed	23.55	24.8	25.75	26.68	28.15
H. Same as G, excluding Ground floor area (usually about 0.7 square foot per square foot of plot)	22.85	24.1	25.08	25.98	27.45
J. Construction rate, in cubic feet per square foot of plot per month from start of demolition to completion including sufficient number of rentals	24.5	24.5	24.5	24.5	24.5
K. Construction time on the above basis in years	1.434	1.51	1.57	1.625	1.775
N. Ground floor rental rate (average) per square foot per year of net rentable or usable area	3.00	3.00	3.00	3.00	3.00
O. Office floor rental rate on the above basis	2.23	2.23	2.23	2.23	2.23

CAPITAL COSTS

	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50
A. Land Value per square foot of plot area					\$ 50
C. Building Cost, including Builder's Profit and Architect's fee, excluding carrying charges during construction					\$ 50
U _a . Taxes during construction (K years) on the Land	190	200	215	215	235.00
U _b . Same as U _a on the Building	1.38	1.46	1.51	1.56	1.71
V. Gross interest on the funds for the above period	2.62	2.91	3.14	3.37	4.02
W. Interest Credit on funds for the above period	91.0	94.25	96.84	99.45	46.80
X. Net interest cost on the funds for the above period	4.93	5.46	5.94	6.40	7.67
Y. Financing cost of fees or discounts on the funds	26.07	28.79	30.90	33.05	39.13
Z. Initial Vacancy Cost (loss of rental during the initial period before building reaches normal occupancy)	20.85	21.90	22.65	23.43	25.42
S. Total capital costs of Capitalization (sum of the following: A, C, U _a , U _b , X, Y, and Z).	15.93	16.77	17.39	18.02	19.00
	306.85	321.83	333.09	344.43	374.28

INCOME

	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50
P. Ground floor income	2.10	2.10	2.10	2.10	2.10
Q. Office floor income	51.00	53.8	55.86	57.98	61.20
R. Total of P and Q if building were 100% occupied	53.10	55.9	57.96	60.08	63.30
T. Same as R if 90% occupied	47.79	50.31	52.16	54.07	56.97

EXPENSES

	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50
Operating	10.60	11.17	11.59	12.01	12.68
Taxes	4.62	4.82	4.96	5.10	5.49
Insurance	.93	0.24	0.25	.26	.28
Amortization	6.43	6.79	7.08	7.37	8.11
Total General	21.88	23.02	23.88	24.74	26.56
Interest, Earnings, and Tax Refunds	25.91	27.29	28.98	29.33	30.44
Percentage on Total Investment	8.44	8.50	8.5	8.51	8.14

TABLE V

CALCULATION FOR THE MAXIMUM BUILDING TO THE POINT OF DIMINISHING RETURNS, BASED ON CARRYING AND OTHER CHARGES, EXCLUSIVE OF THE EFFECT OF ELEVATORS. THE PLOT MUST BE OF SUFFICIENT SIZE TO PERMIT EFFICIENT ELEVATORS. BASED ON LAND AT \$500 PER SQUARE FOOT.

	GENERAL				
	<i>Calculations per square foot of Plot Area</i>				
	\$500 1.00	\$500 1.35	\$500 1.425	\$500 1.50	\$500 1.75
A. Land Value per square foot of plot area	500	675	712.50	750	875
B. Ratio of Building Cost to Land Value	.81	.81	.81	.81	.81
C. Building Cost, including Builder's Profit and Architect's fee, excluding carrying charges during construction	617.5	834	879.6	926	1080
D. Same as C, per cubic foot	18.79	18.79	18.79	18.79	18.79
E. Building Cubage or Volume	33.4	44.4	46.81	49.3	57.50
F. Ratio between Cubage and the net rentable area developed					
G. Total net rentable (or usable) area developed					
H. Same as G, excluding Ground floor area (usually about 0.7 square foot per square foot of plot)	32.7	43.7	46.11	48.6	56.80
J. Construction rate, in cubic feet per square foot of plot per month from start of demolition to completion including sufficient number of rentals	21	21	21	21	21
K. Construction time on the above basis in years	2.487	3.3	3.49	3.67	4.28
N. Ground floor rental rate (average) per square foot per year of net rentable or usable area	30	30	30	30	30
O. Office floor rental rate on the above basis	5.65	5.65	5.65	5.65	5.65

CAPITAL COSTS

	\$500	\$500	\$500	\$500	\$500
A. Land Value per square foot of plot area					\$500
C. Building Cost, including Builder's Profit and Architect's fee, excluding carrying charges during construction					\$500
U _a . Taxes during construction (<i>K</i> years) on the Land	500	675	712.50	750	875
U _b . Same as U _a on the Building	24.00	31.78	33.59	35.30	41.22
V. Gross interest on the funds for the above period	12.00	21.41	23.94	26.50	36.05
W. Interest Credit on funds for the above period	247.90	417.2	463.77	510.50	713.50
X. Net interest cost on the funds for the above period	28.35	53.4	60.34	67.50	99.20
Y. Financing cost of fees or discounts on the funds	219.55	363.80	403.43	443.00	614.30
Z. Initial Vacancy Cost (loss of rental during the initial period before building reaches normal occupancy)	96.00	122.00	138.25	134.30	160.90
S. Total capital costs of Capitalization (sum of the following: A, C, U _a , U _b , X, Y, and Z)	61.70	80.45	84.46	88.60	102.60
	1413.25	1794.44	1886.17	1977.70	2330.07

INCOME

	\$500	\$500	\$500	\$500	\$500
P. Ground floor income	21.00	21.00	21.00	21.00	21.00
Q. Office floor income	184.70	247.00	260.52	274.70	321.00
R. Total of P and Q if building were 100% occupied	205.70	268.00	281.52	295.70	342.00
T. Same as R if 90% occupied	185.13	241.20	253.37	266.13	307.80

EXPENSES

	\$500	\$500	\$500	\$500	\$500
Operating	27.03	35.95	37.92	39.97	46.55
Taxes	19.25	22.61	23.34	24.07	26.45
Insurance	.60	.81	.86	.90	1.05
Amortization	22.83	32.40	34.65	36.90	46.00
Total General	69.71	91.77	96.77	101.84	120.05
Interest, Earnings, and Tax Refunds	115.29	149.53	156.60	164.16	188.00
Percentage on Total Investment	8.15	8.33	8.30	8.30	8.09

TABLE VI
BUILDING DATA

Each line of this table refers to a specific individual building for which the data were given on the understanding that the identity of the building would not be revealed. Certain examples, too easily identified, are not noted in this table though considered in plotting the curve in Graph 14.

LAND VALUE PER SQUARE FOOT	AVERAGE RENTAL RATES		BUILDING COSTS		RATIO BUILDING COST PER DOLLAR OF LAND VALUE	RENTABLE AREA DEVELOPED PER SQUARE FOOT OF PLOT
	Per Square Foot	Per Year	Construction per Cubic Foot	Operation per Square Foot		
	Ground Floor	Office Floors		Rentable per Year		
\$ 20.00	\$ 4.00	\$3.00	\$.60	\$ —	5.35	9.76
41.25	3.60	3.00	.69	.65	3.79	11.10
43.20	—	2.26	—	—	—	9.33
47.00	—	3.00	.60	—	—	—
48.80	—	2.75	—	—	2.72	9.14
50.00	3.00	2.35	.55	.60	3.00	18.43
57.50	4.50	3.00	.64	.686	2.86	13.10
60.00	—	2.75	—	—	4.23	22.20
61.10	6.00	3.00	.49	.50	1.56	14.40
75.60	8.28	2.25	.62	.50	1.768	14.30
78.00	8.60	2.25	.56	—	—	—
80.80	—	2.30	—	.50	1.21	8.75
88.00	—	2.80	.60	.65	1.86	15.25
89.80	—	3.00	—	—	—	10.20
95.00	10.00	1.82	.55	—	1.69	18.72
100.00	—	2.50	—	—	—	—
133.00	7.00	2.74	.65	.55	1.03	11.52
144.00	7.50	3.25	.599	.60	1.105	13.08
150.00	14.05	2.30	.55	.60	.893	15.27
157.00	9.00	2.84	.635	.50	1.0	14.10
172.00	10.00	3.57	.681	.70	1.18	15.97
178.00	—	3.33	—	.70	—	8.79
180.00	—	—	.90	.80	—	22.60
182.00	—	2.50	—	—	—	—
188.00	10.00	3.50	.70	.70	1.488	24.00
191.00	—	3.10	.63	—	1.35	20.60
202.00	15.00	4.50	.66	—	1.00	24.70
203.50	20.00	3.10	.85	.70	.65	11.60
204.50	12.00	2.25	.648	.60	.793	13.20
221.50	—	2.75	—	.60	—	—
222.00	16.63	3.15	.582	.637	.756	16.00
228.00	14.00	3.50	.8075	.70	1.162	16.38
234.00	14.00	3.85	.745	.72	1.367	18.00
235.00	—	5.00	—	—	—	17.45
250.00	—	5.25	.90	—	—	—
250.00	15.00	3.50	—	.70	—	11.20
262.00	17.00	4.00	.60	.60	.928	21.75
278.00	16.00	2.90	—	.60	1.27	8.66
300.00	18.00	4.00	—	—	—	26.58
323.00	20.00	3.00	—	.60	—	10.83
353.00	20.00	4.00	.70	.70	.70	15.48
368.00	—	5.00	.80	.80	.888	25.10
425.00	25.00	5.50	1.00	.77	—	25.18

APPENDIX VI

RENTALS INCREASE WITH HEIGHT AND EXPOSURE

Graphs Nos. 3 and 4¹ show how uniformly office rentals increase with height above the ground. Each of the lines on the graphs represents a well-known skyscraper, but certain of these buildings that are of great and unique height have not been plotted to their tops as to rental rate since this would allow them to be too easily recognized. It was felt necessary to do this to preserve the confidential nature of the data. The rentals at the fourth floor level vary from \$3.00 up to \$5.25 per square foot per year; the maximum rentals on the highest floors, from \$3.50 to \$9.00. The increase in the rental rate per square foot for each story of additional height progresses with surprising uniformity. The average rate of increase is almost exactly five cents per story. It is particularly interesting to note that once a building rises above the general run of its neighbors, the rate of increase per story decreases very rapidly. Thus in New York the curve rises rapidly up to around thirty stories in height and above that level tends to flatten out.

In one prominent new building in the Forty-second Street area the top floor rentals per square foot are twice those of the third and fourth floors. This amounts to a difference of \$300 per unit per floor, which is considered a reasonable increase. This amounts to sixty cents per square foot per year increase per floor, although most increases are somewhat less than this.

According to several of the leading building managers, the popularity of exposure is, first, south; second, east; third, west; fourth, north. The same preference of exposure applies in apartment houses, according to other authorities. However, they go on to say that the variation in rental price would not be over 5 per cent. It is obviously impossible to generalize, particularly about office buildings. The building managers state that the psychology of what rent different tenants will pay is so varied that a competent manager must know his tenants and building business conditions to achieve the best results. It is generally felt that a small tenant, user of from 2000 to 10,000 square feet of space, wants not just so much space but rather so many windows. This type of

¹ See pp. 18 and 20.

tenant is preferred by the average renting agent. One man stated that if a two-window office unit rents for \$2200 per year, the same space with only one window might only bring about \$1500.

Another well-known manager says that the south side is not only the most popular, but that south windows are rated from two to three times the value of north windows, while the west and then the east windows are scaled down in the order named. In a typical new skyscraper in New York, one of the leading building managers described the method used in determining rental rates per square foot as follows: the entire rentable area of the building had a basic net price of \$3.50 per square foot assigned to it. Then each window was evaluated at a given sum of money per year depending upon the exposure and outlook of the window and its location in the building. The floors from the first to the twelfth were not considered in this estimate, being taken either by a bank or other organizations at the start.

FLOORS	NORTH, EAST, AND WEST EXPOSURE	SOUTH EXPOSURE
12-15	\$200	\$500
16-17	300	600
18-26	400	600
27-32	500	600 — should have been even higher

Considering the twentieth floor, the net rentable area consists of 9878 square feet, which at \$3.50 indicates a rental of \$34,573 per year. In the southern exposures there are eight windows priced at \$600 each, or \$4800. On the north, east, and west there are twenty-seven windows priced at \$400 each, giving \$10,800. The summation of factors indicates an aggregate floor rental of \$50,173, and the rental was consequently fixed at \$50,000 per annum.

One building manager maintained that in office buildings a southern exposure would tend to bring in 10 per cent additional rent per square foot. He stated that he believed that about 30 per cent differential would be found in his own buildings between rates on courts at lower stories and rates on street frontages at the upper stories.

A leading building manager in Philadelphia stated that he received the highest rental rate per square foot on southern exposure and on the southwest, the next best on the west, the next best on the east, and the lowest on the north.

Another manager stated that rooms facing on courts in office buildings often, even if the courts are open, are worth from 10 per cent to 25 per cent less than corresponding space on the street frontage.

The following are a number of typical apartment house examples of actual monthly rent variations with height and exposure:

In the Alexander Hamilton apartment house in White Plains the rents per room of each apartment vary from \$2 to \$5 per floor of added height above the ground. Apartments facing the park pay \$10 more.

In the Cambridge Apartment in Philadelphia the apartments pay about \$3.50 per floor of added height. Southern exposure is worth about \$20 additional.

In London Terrace on West 23rd Street, New York, the increase is \$1.50 to \$2 per floor per apartment. Southern exposure pays \$5 more per apartment than northern exposure.

Other New York apartments show the following rent variations:

1185 Park Avenue: an addition of \$100 per year per apartment per floor; sun exposure pays an addition of \$400 to \$600 per apartment per year; outlook over the park shows \$400 additional per apartment per year.

40 East 88th Street: an increase of from \$50 to \$100 per apartment per floor per year; sun exposure shows an increase of \$100 per year; an outlook, from \$50 to \$100.

47 East 88th Street: an increase of \$100 to \$200 per apartment per floor per year; sun exposure adds at least \$100 per apartment per year.

40 East 66th Street: an average of \$100 increase per apartment per floor per year; sun exposure and outlook show an increase of from \$200 to \$600 per year.

865 First Avenue: an increase of \$50 per apartment per year for sun exposure.

340 East 57th Street: an increase of from \$50 to \$100 per apartment per floor per year; variations for sun exposure are \$150 per room.

70 East 96th Street: an increase of \$50 per apartment per floor per year.

240 East 79th Street: rentals increase \$50 per apartment per floor; variation due to sun exposure amounts to about \$12 per room.

1215 Fifth Avenue: the variations with height run from \$50 to \$100; variations with the exposure run as high as \$117 per room.

Graph No. 5 shows a curve indicating the per cent increase in rental value in apartments according to the number of stories above the street.

TABLE VII
RENTALS VARYING WITH HEIGHT ABOVE GROUND
TYPICAL COMPARISON OF CERTAIN NEW YORK OFFICE BUILDINGS

RENTALS IN DOLLARS PER SQUARE FOOT PER YEAR												
GROUND AREA IN SQUARE FEET	CONTENTS IN CUBIC FEET	RENTAL AREA IN SQUARE FEET	STORY HEIGHT	Ground Floor	2d Floor	4th Floor	12th Floor	20th Floor	30th Floor	Top Floor	Average	Lighting¹
					6.00	5.00	5.00	5.75	6.50	7.16	6.50	A
18,000	9,300,000	450,000	10' 6"	30	6.00	5.00	5.00	5.75	6.50	7.16	6.50	A
49,000	24,800,000	1,218,000	11' 3"	20	8.00	5.00	5.25	6.00	7.00	7.00	6.50	A
12,400			8' 8"								5.00	A
17,200	5,000,000	300,000	10' 6"	Owner		3.75	4.25	5.35	5.50	6.50	5.50	B
22,000	12,000,000	585,000	8' 8"	18	15.00	3.10	3.85	4.45	4.90	5.05	4.00	C
26,200		800,000	9' 3"	Owner		5.25	5.50	6.00	6.75	9.00	6.25	B
29,000			9' 3"	Owner			4.25	5.50	6.00	7.00	5.25	A
42,000	14,800,000	850,000		18	9.00	3.60	3.60	3.60	4.90	6.00	4.85	B
37,000	12,500,000	900,000				3.30	4.60		5.60	7.00		B
					7.50	3.25	4.00	4.80	5.00	5.00	4.50	A

¹ Lighting: A = Good; B = Fair; C = Poor

LIGHT RIGHTS OR AIR EASEMENTS

There seem to be a great many cases in our larger cities where the owner of a new tall building considered it worth his while to try to buy the adjoining low building or, if not possible, to lease the light rights over it for a period of years in order to protect the light to the side windows in his own building. For example, J. P. Morgan and Company had a 21-year lease with three renewals on property adjacent to their bank at Wall and Broad Streets. They turned this lease over to the Equitable Trust Company when the latter erected their skyscraper on the adjoining property, with an agreement on the part of J. P. Morgan and Company that the latter would not erect their bank building any higher. This assured permanent light above the third or fourth story to all of the rooms along one side of the Equitable Trust Building.

The Harriman Building Corporation erected a 37-story building at 39 Broadway which would have lost light and view from its side windows if the six-story building at 31 Broadway, next to the south, were to have been increased in height. As it was impossible to buy this building or to buy the lease from the tenant, the Harriman Building bought an air easement above 31 Broadway. This easement was to run for twenty-one years.

Before the Bank of Manhattan Building group owned the Assay Office site, the court toward the latter building could only be used legally to light windows down to a certain level. With the purchase of the Assay site, light can be secured over the latter and windows put in down to the bottom of the court.

The same thing is true in the case of the Chrysler Building on the east party wall where a court could not have windows legally until the Chrysler Building took a lease on the court in the adjacent building on the east; then the windows could be opened on the Chrysler Building court.

APPENDIX VII

OFFICE-BUILDING FINANCING AND BUILDING COSTS

The accompanying tabulation, Table VIII, taken from an article¹ entitled "The Minimum Building for Varying Land Values," by W. R. Morton Keast and A. B. Randall, shows complete typical set-ups for the financing of new large office buildings.

CAPITALIZATION

According to the average practice in financing by means of a bond issue, a first mortgage of 65 per cent on the value of land and building is placed at 6 per cent. A second mortgage of 15 per cent on the value of land and building is placed at $7\frac{1}{2}$ per cent. On the remaining equity of 20 per cent of the total cost of land and building, a return of at least 10 per cent has been allowed. The insurance would amount to .12 per cent on the average of the building cost. The real estate taxes would average approximately 70 per cent of the land and building cost times the average tax rate of 2.75 per cent. The total interest earnings and tax refunds have been calculated to average 7.445 per cent on the total project cost. The operating costs per square foot will vary with the land value per square foot, as shown on the graphs, Nos. 59, 60, and 61 (pp. 156, 158), entitled, "Operating Costs per Square Foot on Varying Land Values."

At this point it is interesting to quote from the same article by Mr. Keast and Mr. Randall.

RATIO OF BUILDING COST TO LAND VALUE

This study analyzes building ratios for present conditions and presents a method for determining an economic building adapted to future trends.

The minimum building — one which will earn 10% on an equity investment of about 20% of the total cost — is taken as a base. The advisability of building beyond this minimum size will depend on the present or probable future demand for space [see Graph No. 8].

A series of calculations similar to that [in Table VIII] yields a ratio of building cost to land cost for each of the varying land values. This ratio is shown on the accompanying Graph [No. 29]. The

¹ *The Architectural Record*, Apr., 1930.

TABLE VIII

A METHOD OF DEDUCING THE MINIMUM BUILDING FOR VARIOUS LAND VALUES

(Based on square feet of plot area and including financing costs)

A	LAND VALUE	#5	25	50	100	200	300	400	500	600	700	#800
B	Ratio	11.00	3.67	2.41	1.72	1.30	1.122	0.99	0.873	0.786	0.72	0.654
C	Building Cost	55.00	91.90	122.00	172.00	260.00	337.00	396.00	436.00	472.00	504.00	524.00
D	Cube Cost	0.27	0.36	0.45	0.55	0.68	0.75	0.79	0.81	0.83	0.85	0.86
E	Cubage	203.8	255	268	313	383	450	501	538	568	593	609
F	Cu. ft. per sq. ft. rent area	16.50	17.82	17.90	18.10	18.25	18.50	18.70	18.79	18.87	18.92	19.00
G	Total Area	12.33	14.27	15.00	17.25	21.00	24.30	26.80	28.65	30.10	31.30	32.00
H	Total Area Excl. First floor	11.63	13.57	14.30	16.55	20.30	23.60	26.10	27.95	29.40	30.60	31.30
J	Const'n. Rate Cu. Ft. per month	22.5	22.2	21.5	20.0	18.8	18.3	18.0	17.9	17.7	17.6	17.5
K	Const'n. Time in years	.753	.959	1.037	1.303	1.695	2.045	2.32	2.50	2.678	2.806	2.90
L	Ratio net rent-able to plot area	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50
M	Number of Floors	23	27	29	33	41	47	52	56	59	61	63
N	Ground Floor Rental Rate	1.053	1.64	2.23	6.00	12.00	18.00	24.00	30.00	36.00	42.00	48.00
O	Office Rental Rate	1.053	1.64	2.23	2.87	3.86	4.60	5.18	5.65	6.11	6.56	6.93
CAPITAL COSTS												
A	LAND VALUE	5.00	25.00	50.00	100.00	200.00	300.00	400.00	500.00	600.00	700.00	800.00
C	Building Cost	55.00	91.90	122.00	172.00	260.00	337.00	396.00	436.00	472.00	504.00	524.00
Va	Taxes during Construction L.	.07	.47	1.00	2.51	6.52	11.82	17.88	24.10	30.90	37.83	44.60
Vb	Taxes during Construction B.	.40	.85	1.22	2.16	4.24	6.84	8.85	10.50	12.17	13.62	14.61
V	Int. dur. constr. inc. Tax Rfde.	3.85	9.65	15.48	31.42	71.72	123.80	180.50	233.20	290.20	346.70	398.00
W	Int. Credit on cash	70	1.53	2.24	4.17	8.73	14.47	20.45	25.55	31.00	36.07	40.28
X	Net int. dur. Construction	3.15	8.12	13.24	27.25	62.99	109.33	160.05	207.65	259.20	310.63	357.72
Y	Fin. Cost	4.92	9.73	14.42	23.35	40.84	58.40	75.10	90.00	104.79	119.30	132.40
Z	Initial Vacancy Cost	3.90	7.02	10.02	15.51	26.03	36.35	45.60	53.68	61.42	69.05	74.98
S	Total Proj. Cost	72.44	143.09	211.90	342.78	600.62	859.54	1103.48	1321.93	1540.48	1754.43	1948.31
CAPITALIZATION												
a	1st Mortgage	47.10	93.02	137.50	222.74	390.39	558.50	716.50	859.50	1002.00	1141.00	1266.00
b	2nd Mortgage	10.87	21.42	31.83	51.48	90.19	129.00	165.50	198.30	231.00	263.00	292.31
c	Equity	14.47	28.65	42.57	68.56	120.04	172.04	221.48	264.13	307.48	350.43	390.00
S	Total	72.44	143.09	211.90	342.78	600.62	859.54	1103.48	1321.93	1540.48	1754.43	1948.31
INCOME												
P	Ground Floor	0.74	1.15	1.52	4.20	8.40	12.60	16.80	21.00	25.20	29.40	33.60
Q	Offices	12.24	22.25	31.89	47.50	78.35	108.56	135.10	157.92	179.60	200.78	216.40
R	Total 100% Occ.	12.99	23.40	33.41	51.70	86.75	121.16	151.90	178.92	204.80	230.18	250.00
T	Total 90% Occ.	11.70	21.06	30.06	46.53	78.07	109.04	136.74	161.03	184.32	207.16	224.94
EXPENSE												
-	Operat'g Rate	.27	.36	.45	.55	.68	.75	.79	.81	.83	.85	.86
d	Oper'g Expense	3.33	5.15	6.76	9.49	14.29	18.25	21.20	23.20	25.00	26.60	27.53
f	Taxes .01925	1.15	2.25	3.32	5.24	8.85	12.27	15.32	18.03	20.62	23.15	25.50
e	Insurance .0012	.07	.11	.15	.20	.31	.41	.48	.52	.57	.60	.63
g	Amortization	1.70	2.93	4.05	6.09	10.00	14.00	17.60	20.58	23.50	26.33	28.08
h	Int. Erngs. & Tax Rfde.	5.45	10.62	15.78	25.54	44.62	64.07	82.14	98.68	114.66	130.48	143.20
T	Total	11.70	21.06	30.06	46.56	78.07	109.00	136.74	161.01	184.35	207.16	224.94

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line [shows a ratio for] full financing It will be seen that, on the higher land values, profitable operation does not require a much larger building with the financing fees added than without; but on land at \$100 or less per square foot the difference becomes very great, so that the fees sometimes double the size necessary for a profitable building.

* * * * *

METHOD OF FINANCING

Financing a project by means of mortgages or mortgage bonds is usually accomplished by one of two general methods. The first is through a *trust company mortgage*, and the second by means of a *bond issue* through investment bankers. There are various types of intermediate methods including the case where a first mortgage is obtained as in the first method, followed by a second mortgage from a building and loan association or similar institution. Such an intermediate method would cost the owner financing fees upon a portion of the capitalization only.

The *trust company* or *institutional first mortgage* is often arranged without financing fees or discounts and is usually granted 60% of an appraisal made by the trust company. This appraisal often does not allow for certain items which enter into the actual cost of the change-over, such as interest during construction on second mortgage and equity value, initial vacancy cost, and architects' and other professional fees. Therefore this 60% of their appraisal becomes less than 60% of the actual total costs.

The bond issue on the other hand is often made upon an appraisal which includes these items and fees in the total costs of the change-over, or on an income basis capitalized, which is substantially equivalent. The security of the real estate permits a first mortgage up to 65% of the total appraisal in New York and other states. The second mortgage and equity are therefore smaller than required under the first method.

It may be observed here that the choice between these two methods depends rather upon special factors affecting the owner. The trust company, since most of its funds are under the jurisdiction of an orphans' court or other legal tribunal, and in fact are estates of one kind or another, usually requires a greater protection in the amount it will loan than the investment banker, who takes the slightly greater risk of the larger issue.

It is therefore not intended to suggest one method as against the other, but rather to figure with the one which costs the most, so that, although these costs may not be required at first, the project will still be in safe ratio to the land value should they be necessary later.

It is also noted that on high values of land the mortgages become of such size that few companies are large enough to take them alone, or are willing to forego the consequent diversification of their funds.

. . . in the *lower range* of land values (from \$1 to \$100) the extra size necessary in the building to compensate for full financing is so great that the tendency here is toward the *trust company's mortgage* method. The trust company can take the entire mortgage without endangering the diversification of its investments, because the amounts involved are small.

Bankers must eventually take a broader responsibility to the community, and to other investors than those applying to them. An individual borrower may have sufficient resources to cover a project which from the standpoint of the community represents inadequate utilization of land, or, conversely, serious overbuilding.

In this analysis the second method, namely that of the *bond issue* and complete financing, will be considered as a fundamental one, and as a proper economic basis upon which a large structure should be designed. The reasons for this include the fact that even though the owner may not elect complete financing, the relation of the risk values of the various parts of the investment are better expressed in this method than in the other.

Only a minority of owners are in the position of having the capital themselves, and should they elect thus to finance a project (without allowing for financing charges in determining its size) this decision may easily work to their future detriment, should they ever desire to sell the land and its improvement. The prospective purchaser, should he require financing, as the majority do, will find that he has to add these costs to his capital expenses when he takes over the property. If therefore the property improvements are designed to produce the requisite return on only a lesser capitalization without financing costs, this rate of return will obviously be less on a greater capitalization with new financing costs included. Such a condition actually implies a lesser value of the property to this majority of purchasers, and a probable loss in resale value to the original owner.

Should the present owner himself desire at any future time to obtain full financing on his property, this basis of calculation will provide him with a proper size of building without loss to himself.

Further, in very large projects, the granting of a mortgage by one institution may mean such a large sum that such institution will be unwilling to forego the principle of diversification of its investments and hence limit the application of the former method of financing.

One type of complete financing may enable an owner to obtain bond issues up to about 80% of the total project cost. These issues will have a cost varying with the conditions of the money market and with the prestige of the project and its owners. However, the average risk values of the various parts of the money entering into the capital cost of the improvement may be expressed as follows: A first mortgage of 65% of the total appraisal at 6% interest and with financing fee or discount of 7 points, yielding a net of cash of 93% of the face value

of the mortgage; a second mortgage of 15% additional at $7\frac{1}{2}\%$ interest (whether obtained by premiums, discounts, or straight interest), at a fee, or discount of 15 points yielding cash of 85% of its face value.

Thus the total financing discounts can be expressed as the sum of 65% of the total at 7 points or 4.55 of the total capitalization, and 15% of the total at 15 points or 2.25%, making the total discount fees equal 6.8% of the total capitalization.

LAND VALUES

Many buildings owe their existence entirely to the need of their owners to cover the accumulated losses accruing on their undeveloped properties in the form of taxes, carrying charges, and interest. Nevertheless the true value of a property is based not on this cost but on its *potential earning capacity*. The value of land is merely the pre-discounting of its potential earnings for a reasonable time into the future.

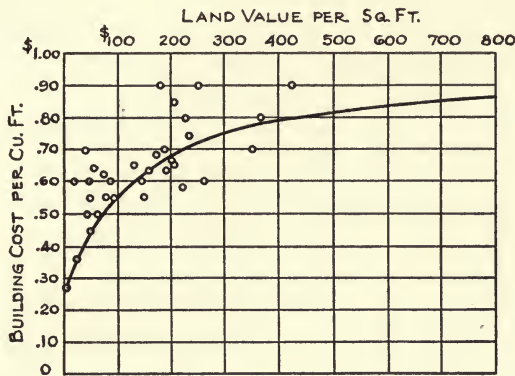
There have been periods and districts in which land values have been inflated far beyond their income possibilities present or future. The return from space is primarily based on the current market; production costs must be adjusted to this income.

There are other cases where, based on the opinions of others as reflected in asking prices, recorded sales, etc., the land costs are considerably above any value that can be warranted or sustained on the basis of the potential earnings of the site if developed to the fullest extent that would be justified by the market and the amount of space that can be added to the amount already successfully rented.

In other cases the land value is based on some valuation process considering its potential earnings at some future time that is relatively remote, and in this case the capitalization of this future value is often not properly discounted back to a fair basis of present value.

With these facts in view, it is useful to know what is possible and what is actually being done on land of varying value so that some yardstick of comparison can be set up as a basis of judgment. Further, it should be realized that in many cases here given, the value of the land has enhanced since the project's inception and thus the buildings are somewhat inadequate, or beginning to become so. It would therefore be reasonable to suppose that in many cases the ratio of building value to land value, the amounts of net rentable area, and the cubage that is constructed per square foot of plot area, are far more likely to be too small than too large.

For the purposes of this discussion, land value will be taken as our known quantity and in general as the yardstick to which other factors will be related.



OFFICE-BUILDING COSTS PER CU. FT.
ON VARYING LAND VALUES

NOTE - CERTAIN EXAMPLES EASY
TO IDENTIFY AND GIVEN IN CONFIDENCE
ARE NOT PLOTTED.

GRAPH-14

BUILDING COSTS

Building costs would include not only the actual cost of construction of the building itself but contractors' fees, architects' and other professional fees, surety bonds, insurance during construction, and also the various carrying costs during construction which can be quite heavy.

In general, office buildings of a large bulk type cost from \$.50 up to \$1 a cubic foot, although very few cost over \$.85. Buildings costing less than \$.50 per cubic foot will be very likely to pass into the loft or garage class, and from this amount they may go down to as low as \$.20 a cubic foot. Graph No. 14 shows the relation between land value per square foot and building cost per cubic foot. The base curve was first shown in an article¹ in *The Architectural Record* of April, 1930, but a number of points have been added since then to the curve as here shown.

One new skyscraper in the Grand Central district on relatively cheap land cost \$.67 a cubic foot. A new apartment house in the same district,

¹ "The Minimum Building for Varying Land Values," by W. R. Morton Keast and A. B. Randall.

also on cheap land, cost \$.75 a cubic foot, and with equipment runs up to \$.82. The land cost about \$35 a square foot.

Another well-known building manager says that the cubic cost of apartment houses varies greatly. One recent large building cost \$.92 per cubic foot, although it was felt that there was no good reason why it should not have been built virtually as well for \$.71. Hotel apartments have cost as high as \$7500 per room. Park Avenue apartments average about \$3000 per room. Some fireproof walk-ups can be had at a bid price of \$1000 per room from many builders. Builder's profit is usually reckoned at from 5 per cent to 6 per cent on the costs, and architect's fees at 3 per cent to 6 per cent depending upon the architect and how much work he does.

Park Avenue apartments cost \$.65 to \$.70 per cubic foot, depending on the finish put in by the builder or owner and the amount of work done by the buyer at his own expense. Fireproof 15- to 16-story apartment houses with elevators are being built for from \$.55 to \$.57 per cubic foot, the larger buildings for \$.55. Suburban 6-story semi-fireproof apartment houses, including elevators and mechanical refrigeration, cost up to \$.42 per cubic foot for the higher-class, garden type of apartment, and down to \$.33 and \$.34 per cubic foot for the Bronx type of apartment.

Another well-known type of apartment costs from \$.65 to \$.70 per cubic foot, and the highest class of Fifth Avenue apartment may cost from \$.80 up to \$1 per cubic foot. However, to-day there is a large oversupply of this highest-class type.

Coöperative apartments tend to cost more than rental apartments, as high-class workmanship and fittings have to be used to attract the right type of purchasers. In fact, often the purchaser has his own architect for his own apartment.

A six-story automatic-elevator apartment with long corridors and few elevators and no cross ventilation can be built currently for \$.46 to \$.47 per cubic foot. A four-story garden apartment walk-up can be built at from \$.45 to \$.50 per cubic foot. Small suite buildings cost more per cubic foot than large suite buildings.

In a recent case near Second Avenue, an apartment house was figured first for fifteen stories. The building would have had 815 rooms at \$620 a room and the estimated cost was \$.58 per cubic foot. The same building was redesigned for thirty-two stories, of which the last twelve were to be in a tower. The building would have had 861 rooms. The cost as estimated would have been \$.60 per cubic foot for the lowest eighteen

floors and \$.78 per cubic foot from the nineteenth to the thirty-first floors. Weighted according to cubage this would give a composite price for the whole building of \$.62 a cubic foot. In this particular case the additional investment as compared with the 15-story building would have been \$265,000 and it would only have brought in an additional \$41,000 gross, or 15 per cent gross. As the land value was \$35 per square foot, it was decided that the 15-story building was a better proposition. There was not unqualified agreement between owners, architects, and builders on this point, however, since income was considered as underestimated for the taller building in arriving at this decision.

A new apartment house on Third Avenue cost \$.65 per cubic foot.

To return to office buildings, a leading architect states that a 20-story building would cost \$.50 to \$.60 per cubic foot and that a 60-story building of the same quality might cost from \$.80 to \$1 per cubic foot. The cost of a 40-story building in between would be about \$.70 per cubic foot. A prominent skyscraper near the Grand Central cost \$.70 per cubic foot. Another large skyscraper near the Grand Central with a great deal of deep office space cost \$.63½ per cubic foot, and another prominent skyscraper in the same district, already mentioned, cost \$.67 per cubic foot.

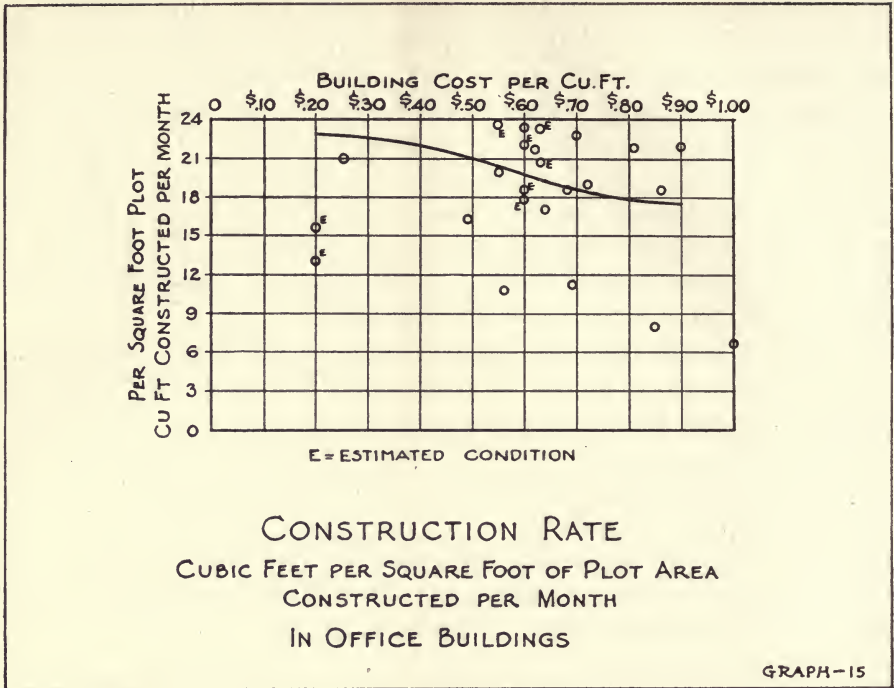
Another well-known architect states that if a 40-story building costs \$.70 per cubic foot, a tower above that level would cost about \$.90 per cubic foot.

CARRYING CHARGES

Mr. Keast and Mr. Randall, in *The Architectural Record* for April, 1930, make the following statement concerning carrying charges.

[Carrying costs during construction] are a necessary cost and capital charge, and enter into the cost of every new building development. From the commencement of demolition to the occupancy of the completed structure, interest must be paid or accounted for on all money expended in the project. If the customary method of a first mortgage bond issue, followed by second mortgage bonds and the balance of equity money, has been employed, interest must be allowed on all these various parts, although a certain credit is allowed on that portion of the cash held by the trustee and paid out by him as the work progresses. State and federal tax refunds are also to be included for this period.

Taxes must be paid on the land assessment during the entire time of the construction of the building. The building assessment will gradually increase over the time of building until at its completion a



total assessment is reached. The average of building taxes will therefore be based on one-half the final building assessment over the period of construction.

The time of construction of a large building will vary from less than a year to upwards of two and a half years in certain cases, commencing with demolition and continuing up to the time of opening, ready for tenants. The construction records of a group of representative buildings were analyzed and plotted and the accompanying graph [No. 15] indicates the average results. It was to be expected, of course, that the less expensively finished types of buildings would be erected at a speedier rate and in a shorter period than expensively finished buildings containing a higher quality of materials, and refinements of workmanship.

When one considers the mounting interest and tax costs, the importance of rapid construction cannot be overestimated.

When buildings become of such size that the time of construction is a factor of great importance in cost, this time may be reduced by the use of additional shifts of workmen.

Some of the speeding can be effected by the delivery of materials at times other than the rush hours on the streets, and this saving has been included in the calculations. The doubling or tripling of shifts

may possibly be carried further. The additional costs involved must not exceed the saving made on interest and taxes over the time involved.

It must also be remembered that some construction records exclude time of demolition, and sometimes even time required for foundations, and only include construction to the time of installation of the first tenant in a particularly favorable location. The time factor included herein has been that upon which interest cost must be based and includes the other items as well as the superstructure of the building.

INITIAL VACANCY COST

This very important cost of "change-over" involved in new construction is frequently overlooked. The owner may realize that the loss incurred from the time demolition starts on the old building until the new building is ready for occupancy should rightly be charged as a cost, yet it is frequently forgotten that this loss or cost continues until such time as the building has reached occupancy and a resultant income which will meet all expenses.

In the period of demolition and construction the costs include taxes on the land and building, interest, and State and Federal tax refunds. In the subsequent period when the building is partly occupied there are added full taxes, the costs of operation, and insurance. Amortization is usually postponed until after the first or second year.

The danger of overlooking the initial vacancy costs is a serious one for an owner who cannot unexpectedly add to his equity investment but must needs meet this additional cost by additional financing. The costs of such refinancing are increasingly heavy and add considerably to the capital costs. Further the carrying charges involved often result in a building that is too small to give a proper return on this increased capitalization.

There are few buildings which attain or hold an occupancy of 100% for any considerable period. Study of office building occupancy shows that the normal average is about 90%, but that this is seldom attained the first year or two. Apartment houses are seldom estimated for normal occupancy of more than 80%, and hotels about 70% to 75%.

A study of a group of buildings built in good districts and held at general market rentals showed an average occupancy at opening date of approximately 30%, secured during the period of construction by renting from the plans. At the end of the first year this would increase to about 60% and the following year to the normal 90% occupancy. This indicates an average occupancy the first year of 45% and the second year of 75%.

A study of the costs that must be met during this period gives a total of about 75% of the possible income, *i.e.* the rent from 75% occupancy. These costs include operating costs, insurance, taxes, interest, and a risk value of 8% on the equity money for its use over

this period. (Amortization is not charged the first year or two. It can be postponed until normal occupation is reached.)

The first year's income of 45% consequently falls short of the costs (75%) by an amount equal to 30% of the total possible income. The second year the accounts approximately balance.

The normal construction time of a four- to six-story apartment is from six to seven months; of a fifteen-story apartment, eight to nine months; of a higher apartment, ten to twelve months. Of course, these vary somewhat with the season. One large office building on Fifth Avenue was recently built at the rate of 15.4 cubic feet per square foot of plot per month. Many buildings have been noted where 18 to 20 cubic feet per square foot of plot are erected each month. In making allowance for time lost in construction, 20 to 22 cubic feet per month per square foot of plot is quite conservative.

INCOME ACCOUNT

As regards the income received from the types of buildings under discussion, instead of quoting from Mr. Keast and Mr. Randall, to avoid largely covering the same ground twice the reader is referred to the graphs and tables in this report on pages 75 and 93 and the notes on page 180.

EXPENSE ACCOUNT

ANNUAL OPERATING EXPENSE

Operating expense, usually figured on a basis of cost per square foot of rentable area in a building, includes the following items: Cleaning and janitor service; heat, light, and power; elevator operation, ventilating, minor alterations, decorating and building repairs; and insurance exclusive of fire insurance on the building.

The Building Owners and Managers' *Experience Exchange Reports* indicate a range of cost from about 50¢ to \$1.00 per square foot rentable area per year, obtaining for a large number of buildings of all ages and in many cities. A study of this item as applied to known buildings indicates clearly that as land values and rentals increase, operating costs may be expected to increase, better service being demanded by the tenants. Operating costs too are greater in an old building than in a new building. A study of a group of representative buildings suggests that the operating cost in cents per square foot of rentable area is substantially close to the building cost in cents per cubic foot. [Graphs Nos. 59, 60, and 61] illustrate the trend of operating costs that may reasonably be expected in buildings suggested on land of varying values.

It is a curious fact, borne out by experience, that a skyscraper costs less to heat per square foot than a building of the same cubage which is spread over the ground, owing to the fact that heat rises. On the other hand, as a matter of operating costs, the repairs are greater on the exterior of a skyscraper than they are on a lower building. This is due to rain and moisture driving into the masonry and to wind abrasion.

Statistics show that the operating cost of some of New York's best-known skyscrapers is from \$.60 to \$.80 per square foot. On the other hand loft buildings run from \$.15 to \$.30 per square foot rentable. This cheaper rate is due to the fact that the tenants clean their own floors and do their own partitioning so that the owner has to take care only of the corridors, stairs, and elevators. Several of the building managers show that on their less important buildings operating costs were running about \$.50 per square foot. Some suburban apartment houses are being operated at 40 per cent of the gross rent roll, including taxes, repairs, decorating, etc. Others state that the operating expenses, including taxes, but excluding interest on mortgages and profits, vary between 20 per cent and 50 per cent of the gross annual rent. The latter figure is due to the high cost of redecorating the better type of apartments.

REAL ESTATE TAXES

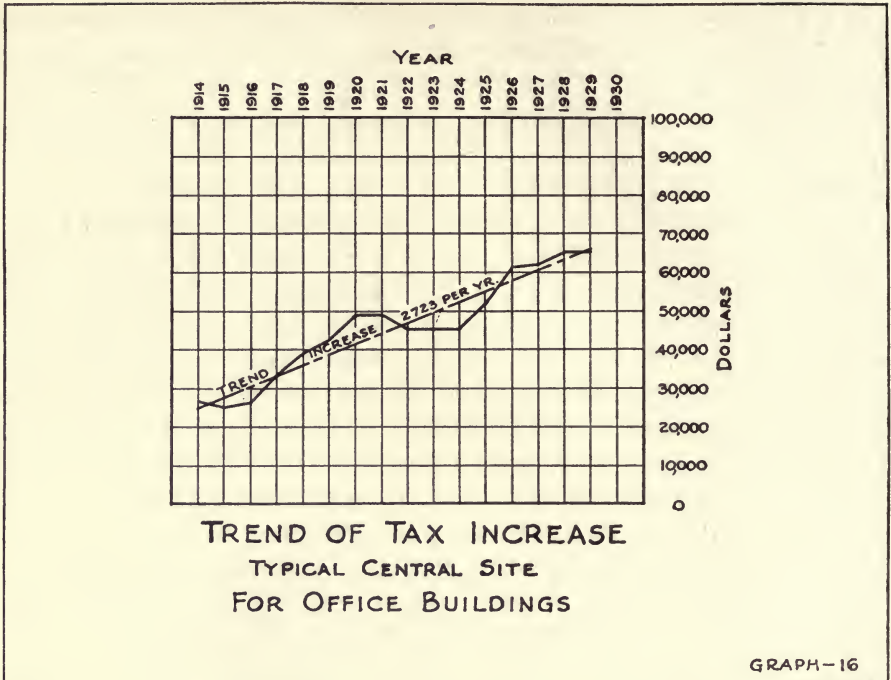
Again quoting from *The Architectural Record* article :

[Taxes] may be divided into two general classes, that of the *city or real estate tax*, and other taxes such as the Federal Income Tax of the owner, or certain state and federal tax refunds on the bond issues. This last item is best considered with the interest costs. The income tax of the owner has not been included in this study.

The *real estate tax* consists of two principal factors, the total tax rate and the basis of assessment. From general observation, an average of \$2.75 per \$100 of valuation assessment, and an assessment basis of about 70% of the value of the building and land value, have been taken as representative of the general cross-section. This rate as well as the basis of assessment may vary somewhat, but the product of these factors seemed generally to converge.

One of the most prominent building managers in New York states that he is accustomed to figure taxes as follows :

Take the total project cost, which is about 30 per cent more than the total cost of land and building, and then assume that taxes would amount to about 3 per cent on from one-half to two-thirds of the total project costs. Or again, with the tax rate at about \$2.70 per hundred, he would multiply this rate by about three-quarters of the total project cost.



INSURANCE

Still quoting as before :

[Insurance] cost is one of the smallest in the annual budget, but warrants consideration since a variation may involve a large sum-total for the life of the building. When a section or zone devoted to garage use is included in the building, or some other use that is considered more hazardous than offices, the insurance rate may be expected to increase. An instance is known where the inclusion of certain garage floors resulted in a rate of about 30c. per \$100, while in another instance of a building with a low hazard, the rate was less than 10c. In this study an average rate of 12c. per \$100 has been taken as a reasonable average for office buildings.

DEPRECIATION AND OBSOLESCENCE

The tangible factors limiting building life have been termed *depreciation*, or a gradual physical wearing out of the building's component parts. The intangible factors have been termed *obsolescence*. These include changes in style, uses, and customs, advances in the art of construction which render the old building less desirable to tenants, losses

in light and air due to the construction of neighboring buildings, and losses due to *inadequacy* or other causes.

Inadequacy is of paramount importance since it may cause a building to become valueless even though physically still excellent. Land value may have increased twofold to fivefold, with a corresponding increase in tax burdens and interest value. Rentals may have increased, but not proportionately, since competition from newer buildings tends to force rentals from obsolete buildings downward. Net income eventually disappears; the building has become obsolete due to inadequacy and must be replaced.¹

INTEREST EARNINGS AND TAX REFUNDS

Various building managers state that second mortgages usually must be amortized to the extent of one-half of the loan within five years' time. On most second mortgages of a five-year duration there is figured a discount of 4 per cent per annum or 20 per cent total. Usually on a five-year loan, particularly on second mortgages, there should be a net return of at least 10 per cent per annum. A first mortgage comprising about 65 per cent of the project's cost may be obtained at a discount of about 5 per cent.

Graph No. 16 shows tax increases over a term of years of a certain central business district property, and is in general indicative of the conditions throughout the large cities of the country.

Again quoting :

The tax refunds, when paid at the source by the owner, are practically an additional payment for the bond holders. The Pennsylvania State Tax is typical of the state taxes: it is four mills on the bond issue, which may be substantially 80% of the project cost. The Federal Income Tax Refund amounts to 2% on the mortgage bond interest.

The total of interest, equity value, and tax refunds during construction, may be added together as follows :

First Mtge.	6 % on 65% total is equivalent to	3.9 % total
Second Mtge.	7½% on 15% total is equivalent to	1.125 % total
Equity value	8 % on 20% total is equivalent to	1.6 % total
State tax at	.004 on 80% total is equivalent to	.32 % total
Federal tax	2% on int. 1st & 2nd Mtge. 5.025% is	.1005% total
Sum of costs above is equivalent to		7.0455% of total

The interest, equity earnings, and tax refunds after construction, give a total sum as follows :

¹ For a more detailed discussion of Obsolescence, see Appendix IX, p. 119.

First Mtge.	6% on 65% total is equivalent to	3.9	% total
Second Mtge.	7½% on 15% total is equivalent to	1.125	% total
Equity earn.	10% on 20% total is equivalent to	2.	% total
State tax ref.	.004 on 80% total is equivalent to	.32	% total
Federal tax	2% on int. 1st & 2nd Mtge. 5.025% is	.1005%	total
Sum of annual charges above is equivalent to		7.4455%	of total

The interest payments include interest on the first and second mortgages with additional costs for tax refunds paid at the source.

The rate of the first mortgage may be taken at 6% per year. Favorable conditions may reduce this slightly; however, other factors such as the type of building, its character and quality, may increase the rate due to increased risk. Hotel and apartment projects are possible examples of this.

The risk of the *second* or *junior mortgage* is greater than that of the first, and this is reflected in the interest rate. A fair average of 7½% interest per year may be taken as a general cross-section, although this in name is not universally applicable. In states where a lower legal limit is set for interest rates, it is customary to obtain compensation for the increased risk of the second mortgage by means of additional fees, discounts or premiums, as in building and loan associations.

Equity earnings, which may be considered as an interest cost to be met annually, have been set at a minimum of 8% during the construction and the initial period of the building, and at 10% thereafter. This was considered the least that would reasonably attract investors, with the risk involved. The minimum building has been calculated on this basis. Larger buildings would sometimes increase this rate under advantageous conditions, and would thus provide more attractive propositions.

The crux of the whole problem of office building and apartment building financing is, what is the minimum return on the equity which will attract new capital into the field? Various owners and building managers say that it is from 15 per cent to 18 per cent. A few say they are not interested unless they can see 25 per cent. However, it would seem evident from the available facts that most big buildings constructed since the War actually pay less than 15 per cent net on the equity, and that a majority pay less than 10 per cent. The question of interest on the equity is very closely tied up with the question of land values. A particularly successful promoter states that his corporation never goes into a building project unless they are confident that there are substantial possibilities to justify a land value at double the existing price. In other words, if they could buy land at \$100 per square foot they would not go into the venture unless the building, when constructed, could be counted

upon to bring in enough revenue to justify a land valuation of at least \$200 per square foot with the taxes and operating expense to correspond.

On apartment houses it is found, in practice, that in most moderate-sized apartments an adequate gross income is usually considered to be about 15 per cent of the cost of building and land. Apartment operators and managers find that the contingencies and miscellaneous expenses during construction generally total about 15 per cent of the cost of building and land, so that the total project cost for apartments would usually run about 115 per cent of the sum of these two items. This might be from 2 per cent to 3 per cent higher where bond issues are undertaken.

APPENDIX VIII

BULK AND FORM OF BUILDINGS

Graph No. 9, showing the proportion of space over twenty-five feet back from the window in a New York building under the present zoning laws, is most illuminating. It is believed to be typical of the many skyscraper office buildings. It shows, first, that in the lower part of the building there is over twice as much space located more than twenty-five feet from a window as there is in the tower. In percentages this is even more striking, for the graph shows that the lowest 16 per cent of the building height contains 27 per cent of the total area of the building.

If we study the line in Graph No. 9 which shows percentages of the total income at each floor level, we see that the lowest one-sixth of the building above the ground floor is only earning 19 per cent of the total income, while it occupies 27 per cent of the total net area. In the second one-sixth of the building it earns $16\frac{1}{4}$ per cent of the total income and occupies nearly 22 per cent of the net area of the building. In the fourth one-sixth the percentage of the total income and the percentage of the total area are the same. On the other hand, by the time we reach the top one-sixth nearly 8 per cent of the total revenue is earned by 6.84 per cent of the total net area of the building.

When we come to the percentage of the total deep area of the building (that is, over twenty-five feet back from windows) we find that the stories below the second take 38 per cent, while the lowest one-sixth of the height of the building above the second story takes $26\frac{1}{2}$ per cent of the total deep area. These curves show strikingly that it does not pay to create too big an area in the lower part of a skyscraper, with the excessively deep and relatively gloomy offices in the lower part of skyscrapers commanding so much less rent, and that it would obviously pay to cut down the rentable space and correspondingly cut down the cubage in these lower areas. This shows perhaps even more strikingly in Table IX, "Utility of Rentable Areas."¹

¹ See Table IX, p. 110.

A leading tall-building financier stated that the elimination of building bulk between the fourth and the sixth floors, and in fact all the way up to the tower, was in the interest of good economy, provided corresponding space in the tower could be substituted. This would apply to buildings on an interior lot, not on a corner.

In the case of the Empire State Building, it is a well-known fact that Mr. Raskob asked to have the cubage cut down in the lower regions of the building to show better returns, and the result is that the building only goes up five stories on the street line and then sets back all around. The New York Life Building sets back above the fifth floor for the same reason.

In the case of the Empire State Building, the first thought was to create many deep offices and much office space, but it was found that where the front or space near the periphery or the windows might bring \$3 to \$4 per square foot, the unlighted rear space would not bring over \$1 to \$1.50. Then it was also found that the actual cost of construction for \$4 space and upward was very little more, relatively, than that for the dark space on the lower floors back in the center of the building. It was decided to go up to the fifth floor before stepping back, as stores, banks, insurance offices, etc., would take the first, second, and third floors, while bank clerical help would probably be able to absorb the fourth and fifth.

Stores and banks can mushroom out by going up: that is, with small ground floor space they can often use to good advantage much larger areas in the floors above. In Chicago, for example, there are various shops that have an entrance and display window on the ground floor and transport customers up eight or nine floors to their real sales and display rooms. In the Daily News Building, the whole building was set back about twenty-five feet from the side lot line above the eighth floor. The sacrifice on the floors above was believed to be more than made up by the gain below.

In the new Salmon Building at Fifth Avenue and Forty-second Street a side yard twenty-five feet wide, starting about five stories up, has been provided between the new building and the next building to the west.

It seems to be generally felt that as much rent can be obtained for a front foot with from 65 feet to 70 feet in depth as for 90 feet to 100 feet in depth, therefore it is wasteful to make stores over 70 feet deep.

As to the bulk and form of the building itself, there seems to be quite a general feeling on the part of building managers and leading architects

TABLE IX

UTILITY OF RENTABLE AREAS
FIGURES ESTIMATED FROM PLANS AND RENTAL SCHEDULES

ZONES	TOTAL USABLE AREA	TOTAL INCOME	TOTAL AREA OVER 25 FEET FROM LIGHT	DEPTHS IN AD- DITION TO 25 FEET		COMPOSITE AVERAGE OF DEPTHS IN AD- DITION TO 25 FEET	PERCENTAGES			
				Maximum	Minimum		Zone Area to Total	Zone In- come to Total	Deep Area in Zone to Total Deep Area	Deep Area to Total Zone Area
Ground Floor . . .	99,000	\$1,455,000	49,959	50	6	30.8	13.80	27.81	38.23	50.45
Intermediate Lower . . .	193,678	1,003,475	34,447	50	6	15.65	26.96	19.15	26.38	17.80
Intermediate Middle . . .	156,209	848,500	20,286	20	7	13.63	21.77	16.23	15.51	12.98
Intermediate Upper . . .	99,183	612,650	13,272	18	2	14.14	13.80	11.72	10.15	13.38
Tower Lower . . .	60,207	431,600	5,945	18	14½	16.06	8.38	8.27	4.54	9.86
Tower Middle	60,758	471,500	5,040	15	13	13.00	8.46	9.03	3.85	8.30
Tower Upper . . .	49,073	406,950	1,760	13	8½	11.28	6.83	7.79	1.34	3.58
TOTALS . . .	718,108	\$5,229,675	130,709	50 Highest Maximum	2 Lowest Minimum		100.00	100.00	100.00	18.20 Total deep area to total us- able area of all zones

that the 25 per cent of the lot area, which is permitted for towers in many zoning ordinances, should be increased somewhat but in exchange for less bulk elsewhere in the building. There seems to be also quite a general feeling that the setbacks or side yards should be encouraged or required between buildings facing on the same street at a level of about sixty feet up from the sidewalk, and that this would do more good than setbacks on the front and rear only.

It seems to be generally felt, too, that where towers are placed centrally on a lot, abutting courts and yards should be considered to have their surrounding walls no higher than the main roofs of the building, and that the tower wall should not determine the dimensions of abutting courts as now required by the interpretation of the present New York zoning law.

There seems to be a general feeling that the apartment coverage should not be reduced too low. It is felt that for the typical city apartment house, lot coverage below 50 per cent is not economical, and that anywhere up to 55 per cent or 60 per cent is a minimum for profitable returns. However, on exceptionally low land values a garden type of apartment covering a small percentage of the lot could be made to pay. On the other hand several leading apartment-house developers say that what the newspapers term "quality production" with minimum coverage, gets the highest return. In other words, high-class apartments can be built to cover only 50 per cent or less of the lot. There are at least four such apartments on East 57th Street, and at least four or five others on Park Avenue.

The Bronx or Queens five- or six-story apartments can be built profitably on a 55 per cent coverage according to the testimony.

At Jackson Heights in Queens they have been built profitably on a 40 per cent coverage when land values were around \$200 per front foot, but now that land values have reached \$500 and even \$1000 per front foot, it is said to be unprofitable to build on less than 50 per cent or even more.

In some cases tower height is limited by the laws of supply and demand in the district, while in other cases building economics govern. One prominent builder uses the following rule of thumb to determine whether more tower should be built or not. Above sixty stories $1\frac{1}{2}$ per cent of the rental area below will be sacrificed for each additional floor above. For example, in a tower covering 20,000 square feet gross and 14,000 square feet net, eighty square feet sacrificed on each of the seventy floors below

constitute 5600 square feet. On the other hand, the gain for each added floor is 14,000 square feet, or the net gain would be 8400 square feet. The cost of each additional story at about \$.90 per cubic foot would be about \$200,000. The total yearly charges and operating costs at 12 per cent would be about \$24,000 per year. The return on 8400 square feet at \$5 per square foot would be \$42,000. Thus the net gain is \$16,000.

In the above calculation, the extra cost per square foot for floors above the fiftieth or seventieth is probably too low and a $1\frac{1}{2}$ per cent area loss on the floors above is probably too small. For example, it is stated by one well-known manager that each 20,000 square feet of added net rentable space requires the entire services of one elevator. He gives an assumed case where a floor between the twentieth and the fortieth story covers 8000 square feet net area. If the building is carried up to sixty stories, there is thus added a constant tower with 20 times 8000 square feet, or an additional 160,000 square feet. With eight additional elevators for this area alone, or six at a bare minimum, eight elevator hatches forty to sixty stories in height would cover fifty square feet apiece and in practice nearer seventy-five, which would mean that they would take out from 8000 to 12,000 square feet, or the equivalent of eight to twelve floors. Thus the increment of usable space may be largely balanced by the space that has to be given up on the floors below in order to serve it.

If the net rentable area in a tower falls much below 60 per cent and consequently below 50 per cent of the gross area, it becomes quite uneconomical. With good design it ought to be possible to get 70 per cent of the typical floor. This implies that it should be large enough so that the elevators and tower utilities can all be located in the dead space in the center with an uninterrupted rim of net rentable space all about the periphery.

A leading building manager states that the dimensions of a tower depend utterly on the price factor, — that is, the rentals per square foot that can be obtained. If dark interior space in the tower can be rented at a large amount per square foot, it can obviously be rented farther down in the same building, thereby making unnecessary the sacrifice of a lot of dark space down below to provide space for elevators to towers.

An architect who has designed some of the most successful towers in New York states that traffic corridors in a tower should be seven feet wide in the clear, and minor corridors five feet wide. He said he never counts corridors all around the central utilities and elevators, but the corridors should be arranged so as to give access between the elevators

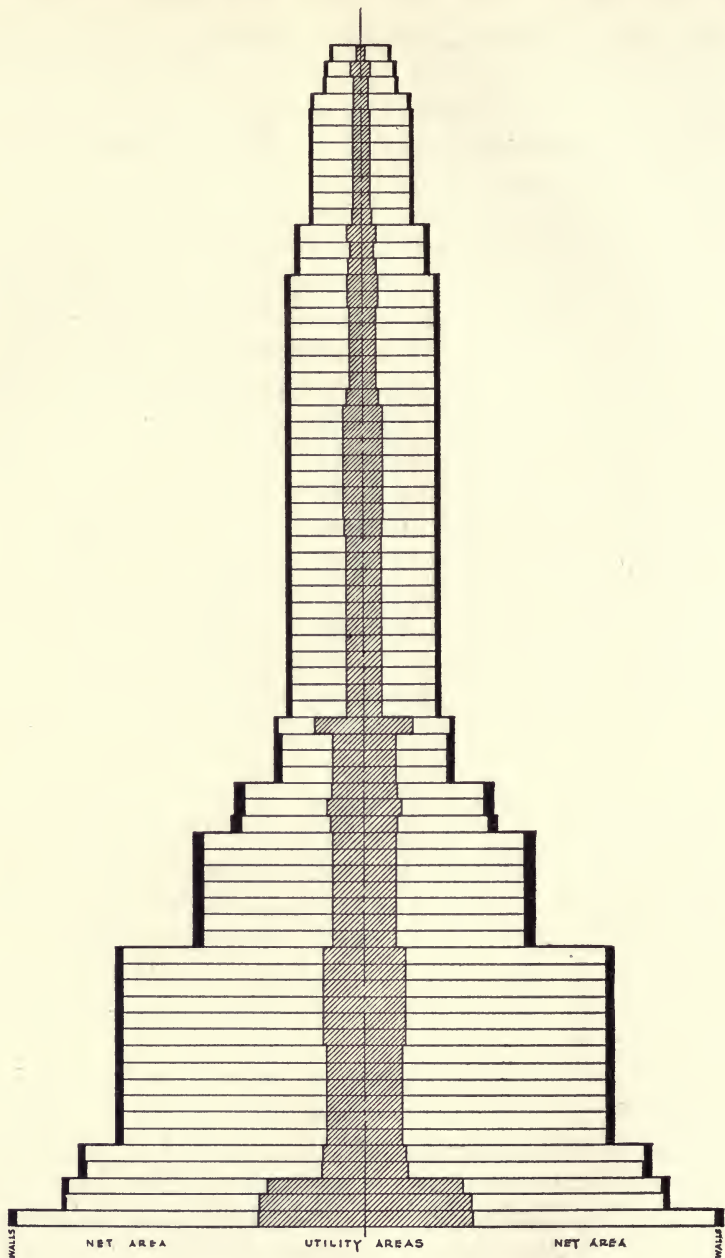
or at either end of the bank of elevators to the rental space behind them.

Mr. Shreve, of Shreve, Lamb & Harmon, architects, states that in a tower like the Empire State Building, on the old Waldorf Astoria Hotel site, the amount of space in the tower that would be taken up by utilities would be almost constant in size all the way up.

Graphs Nos. 17 and 18 show the cores of utilities as they actually work out in two leading skyscrapers. Elevators, stairs, essential public quarters and spaces for toilets, shafts, pipes, etc., are all shown in the solid area in the center of the building. The area lost in the thickness of the exterior walls is shown in the exterior silhouette of the building. However, this silhouette of the building is not a cross-section but rather the width at each floor level is proportionate to the gross area at that floor level. In the case of one building, over a third of the gross area is taken up by the public utilities on the first and second floors; whereas, in the other building, the area taken up by the public utilities is a little less than a third or a little more than a fourth of the gross area up to six stories. This difference is not surprising because it corresponds to the difference in demand between the Forty-second Street area and the Wall Street area, for in the latter the lower five or six floors are in active demand for banks, insurance companies, and brokerage offices that need ample public access.

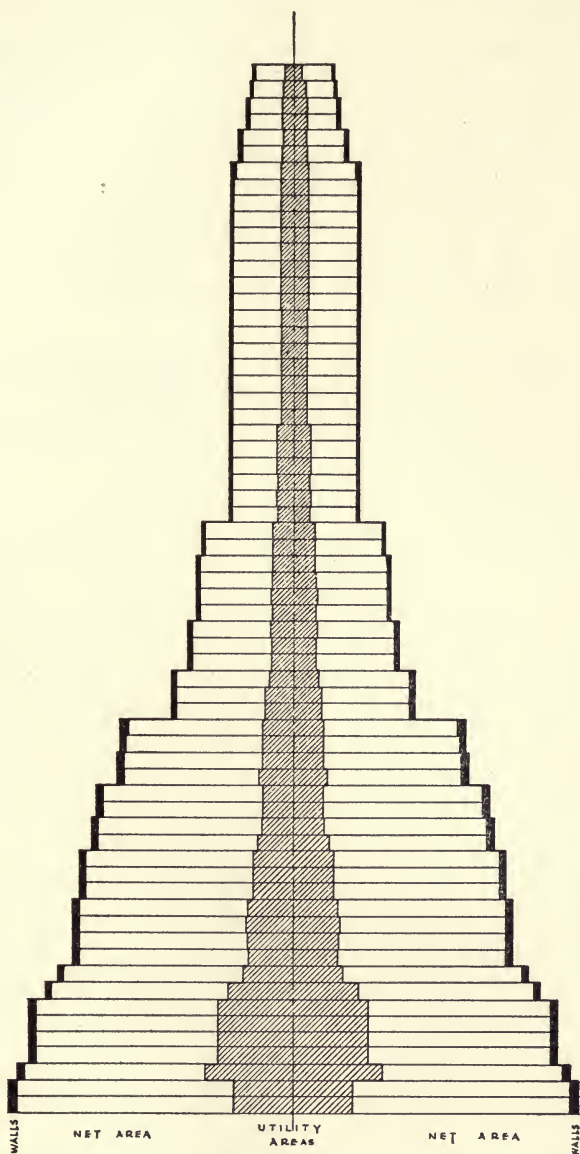
In the case of one building, the core of utilities remains only about a sixth of the gross floor area up to the seventeenth floor, until it surprisingly becomes over a third of the gross area from the twenty-seventh to the thirtieth floors. From there on up throughout the height of the tower it is about a fourth. The same is approximately true in another building, although in the latter building the core diminishes more logically than in the former building, the aggregate effect being about the same in both instances.

The surprising thing about these cores of utilities is that they prove rather conclusively that the relative amount of space lost on the lower stories of skyscrapers on account of the dead run of extra elevators and other utilities to the upper stories is nowhere nearly so large as is often supposed. In other words, the loss on the lower stories of skyscrapers due to the extra utilities that must be provided for the top stories, is a much smaller factor in deciding upon the economic height of towers than has been often maintained. The tower *per se* is much more practical economically than is often thought.



FIGURES ILLUSTRATING THE CORE OF UTILITIES, GROSS & NET AREAS
ON A TYPICAL NEW OFFICE BUILDING

GRAPH-17



FIGURES ILLUSTRATING THE CORE OF UTILITIES, GROSS & NET AREAS
ON A TYPICAL NEW OFFICE BUILDING

GRAPH 18

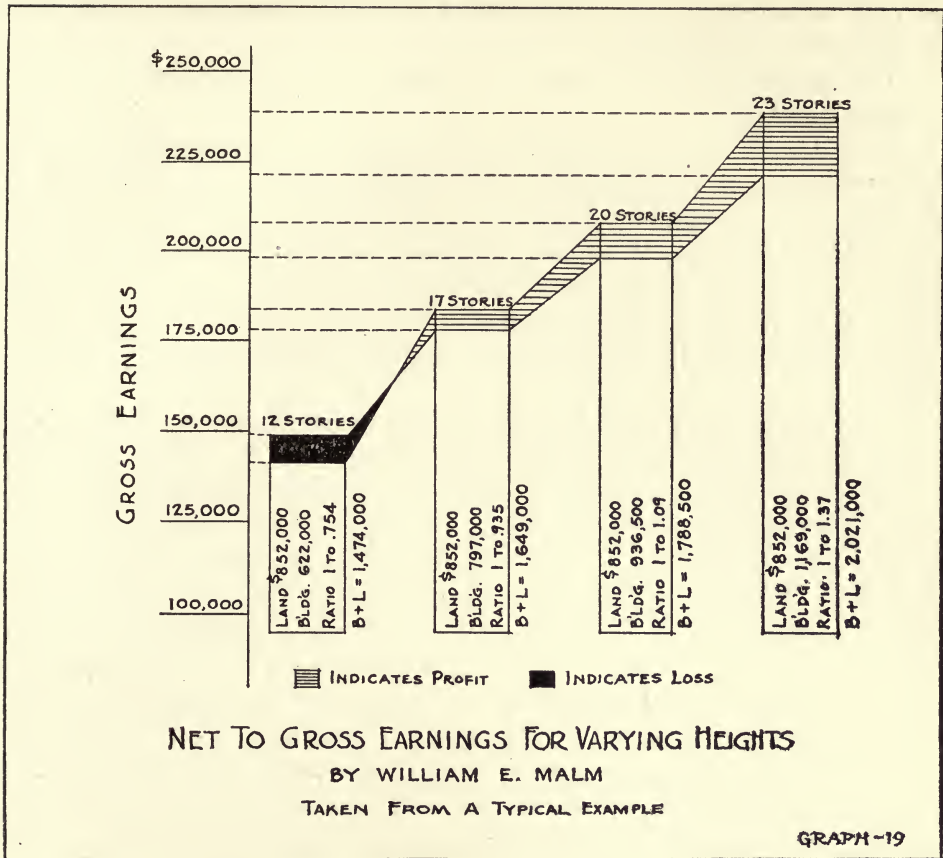
Each elevator, according to the consensus of experience, would serve from 20,000 to 22,000 square feet of net rentable area. However, if the operators of the building keep up the 25- to 30-second interval between cars, which the tenants usually demand, then there will have to be one elevator for every 15,000 to 17,000 square feet of tower area. This means about one hundred and sixty people in the tower per elevator. If there is a car every thirty seconds and each car holds sixteen people, it would only take five minutes per floor to empty it. However, since the stopping of one car every thirty seconds at each floor is based on the assumption that each car on every trip serves many floors, the 5-minute emptying period would probably be nearer forty-five minutes in practice.

Mr. William E. Malm of Cleveland cites an interesting example of office-building analysis in his report as Chairman of the Committee on Height Limitation of the National Association of Building Owners and Managers in 1928 at St. Louis.

He prefaces his discussion of the example by stating that the high unit cost of land is a prominent factor in the determination of office building height. Following this he describes a parcel of land in an eastern city belonging to a corporation desiring banking quarters for their own institution. This site is quite a small one, being 50 by 100 feet. Additional property could not be purchased reasonably. The valuation of the land used was stated to be below both market prices and the value reflected to it by tax assessments. Mr. Malm then states that although the land value is set conservatively, they figured store and office rentals at prevailing peak prices and operating and other expenses were calculated according to conditions in the city. The estimates omitted bond sinking funds or other forms of liquidation of indebtedness, but included reserves and expenses to safeguard the investment. It should be noted that in this particular example the building was constructed seventeen stories high and, although the owners received peak rentals, they could not make the project profitable. It would appear that the building should have been at least twenty-three stories high.

Graph No. 19 indicates the results of his study, assuming different heights of buildings.

It is significant that a 12-story building would not show income to meet expenses, while a 15-story building would just show a balance of income and expenses, if 100 per cent rented. A 20-story building would show a nominal return if 100 per cent rented, but would only just balance



if 85 per cent rented. (In the foregoing calculations a 10 per cent vacancy or a 90 per cent occupancy was used to determine probable gross income.) Mr. Malm's conclusion showed that a reasonable profit with earnings on the investment would only be obtained when the building reached approximately twenty-five stories. Mr. Malm concludes his study by stating that land values can only be based upon an assumption that the plots can be adequately developed in their best use with an adequately situated building. Curtailing and limiting the size of a building will only tend to reduce potential income and hence land values to a degree commensurate with the rigor of the restrictions. Mr. Malm contends that present tax assessments are only possible upon land values based upon maximum economic development, and that it does not follow that limiting and curtailing land values in one locality will enhance land values in

all other districts to such a degree that the total assessments of the city are equalized or increased.

The example given is a most interesting one, but nevertheless open to some question.

Consideration must be given to the probable future conditions that will prevail about the particular site. In Mr. Malm's paper mention is made that the abutting land was so developed as to preclude the purchase of additional land for the more economical development of the site discussed. The exact conditions cannot be known fully from this description. However, it is indicated clearly that the adjacent sites are probably developed by their owners in a manner commensurate with their value.

An ever-present source of danger exists under these conditions since it may be that they are in a state of flux. Adjacent buildings which are to-day profitable to their owners may soon become unprofitable, due to mounting taxes and the inadequacy of returns. This condition may be seen in any city and on all sites and might be expected to lead to the demolition of abutting buildings and their replacement with much taller projects. Under such conditions and considering the possibilities of the particular site over a term of years, a 25-story building on this site would only be an economical project in the event that neighboring construction would not greatly depreciate rental values on the building.

The benefits of zoning practically need no further proof when consideration is given to these possibilities. However, zoning on the basis of an arbitrary measure of sheer height does not fulfill requirements. For example, a 25-story building covering a given percentage of the plot, or set back in some manner, such as is now in force in the city of New York, may be far inferior to an alternative scheme of a higher building in which either the coverage of the building on the plot may be less than that required by law or the setbacks even more drastic than legally provided.

Decreases in the bulk of the base or lower portions of the building, compensated for by larger or higher towers, may well afford protection to the investment over a period of years.

APPENDIX IX

OBSOLESCENCE AND VACANCIES

OBSOLESCENCE

Many people believe that the increase in the value of land offsets any possible decrease in the value of the building. This is based on the assumption which is found to be sometimes true in practice, that value actually does increase at the same rate as that at which the building outlives its usefulness. However, there is still another aspect of this subject, even though land value increase should balance the decreasing value of the building, and that is the striking fact that the original equity would probably be quite inadequate to build a structure of the size and character that is required on the present land value. In other words, as land values increase the owner should increase his equity in order fully to protect himself.

The replacement costs usually increase progressively with time. The cost of repairs and renewals must be added to the capital account. Over a long period there will often be several replacements of the same thing.

As a general rule something like one per cent of the total project cost less the cost of the land will have to be spent each year for depreciation, maintenance, and replacement. In one particularly well built building this cost is as low as one half of one per cent, but others more nearly average two per cent.

In general practice it is found desirable to set aside another one and a half per cent as a sinking fund bearing at least five per cent compound interest to allow for obsolescence.

According to a statement¹ by Mr. Earle Shultz, then Vice President of the National Association of Building Owners and Managers, obsolescence should be defined as "a going out of use" or "a going out of style."

It represents a falling off in the value or usefulness of a thing from causes outside of the thing itself as distinguished from the effects of

¹ Supplement to the April-May Bulletin, 1922, of the National Association of Building Owners and Managers, on "The Effect of Obsolescence on the Useful and Profitable Life of Office Buildings."

wear or physical deterioration. . . . A woman's dress is obsolete as soon as a new style is put on the market. . . . In other words, obsolescence is that which causes the useful and profitable life of anything to be shorter than its possible physical existence.

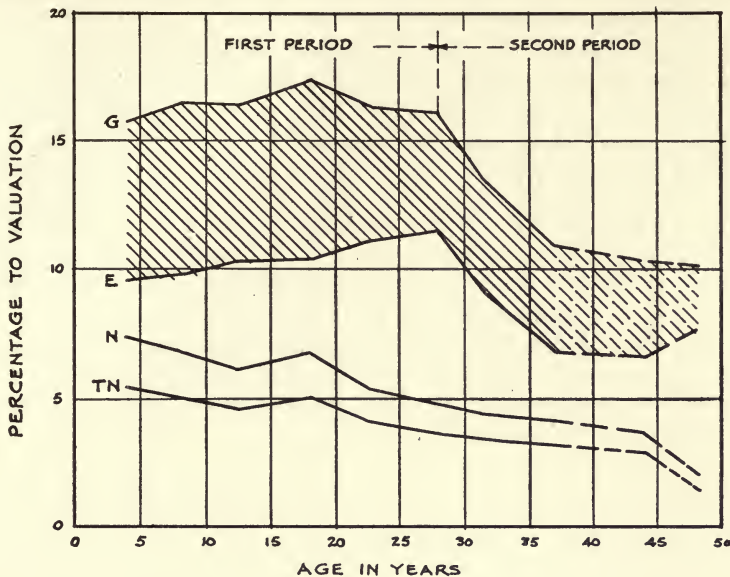
* * * * *

To determine the effect of age on the income and expenses of office buildings, the figures of the one hundred and fifty-five buildings reporting were used. These buildings were first grouped by age into five-year groups, beginning with naught to five years, and extending to forty-five to fifty years. For each group was then computed the average gross income, expenses and net income of the buildings in that group. These averages were then plotted [see Graph No. 20]. On this chart the horizontal scale represents age in years and the vertical scale the percentage of gross income, net income and expenses to the total valuation of land and building. The upper solid line "G" shows the effect of age on the gross income; the . . . line "E" the effect on expenses; and the . . . line "N" that on net income. The space between [line G and line E] also represents net income. The curves are shown dotted from thirty-five years on because only 5% of the buildings reporting were more than thirty-five years of age. . . . No definite conclusions could therefore be drawn from the statements of the few buildings exceeding that age. As the curves G, E, and N represent the percentage of gross income, expenses and net income, respectively, to the tax valuation of the properties, they are necessarily considerably higher than the percentage which the same items would be to the full true or market value of the properties. For all the buildings reporting, the assessed valuations, as given, represent probably about 75% of the true value. The curve marked "TN" gives the true net income of these buildings as the percentage of return on the true market value of the properties.

The item of expense, as used here, includes ordinary operating costs, plus routine repairs and alterations, plus insurance, property taxes and depreciation (as taken). The net return includes not only the net return on the owner's equity in the property, but also all amounts paid to capital represented by the property, whether paid as ground rent, bond interest, interest on notes, etc., as well as amounts paid for all taxes based on income such as income and excess profits taxes, etc.

It will be seen from [Graph No. 20] that the life of an office building may be divided into two periods.

Period 1 extends from the erection of the building to about the twenty-eighth year. During this period the gross income is nearly constant. The expenses, however, rise continuously with a corresponding falling off in the net return. This period represents the useful and profitable life of an office building during which it is earning an adequate return on the investment. During most of this period, the buildings are



G = EFFECT OF AGE ON GROSS INCOME. E = EFFECT ON EXPENSES.
 N = EFFECT ON NET INCOME. T.N. = TRUE NET INCOME OF THESE
 BUILDINGS AS THE PERCENT OF RETURN ON THE TRUE MARKET
 VALUE OF THE PROPERTIES

EFFECT OF AGE ON INCOME AND EXPENSES

FROM "THE EFFECT OF OBSOLESCENCE ON THE USEFUL AND
 PROFITABLE LIFE OF OFFICE BUILDINGS" BY EARLE SHULTZ. 1922

GRAPH - 20

able to maintain themselves as first-class buildings housing the best grade of tenants.

Period 2 extends from the twenty-eighth year to the end of the building's life. During this period the gross income of the building falls very rapidly as also do its operating expenses, while the net income continues to decline at a somewhat faster rate than during the first period. At the beginning of this period the building finds that through the action of obsolescence in any one or more of its several forms it is losing its better class of tenants and that it is impossible for it to maintain its income at its previous level. Because of this falling off in income, it must necessarily reduce its operating expenses in proportion by giving a cheaper grade of service, thus becoming a second grade building. In spite of all that can be done to reduce operating costs, the ever increasing amount of repairs and replacements necessary in an old building serve to increase expenses with the result that if the

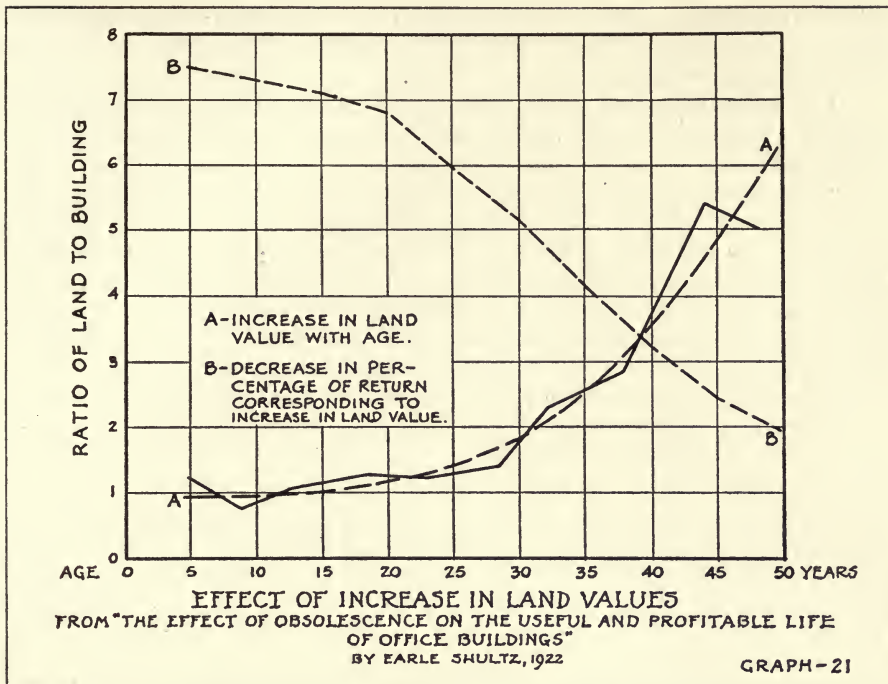
building continues in existence, it soon becomes a non-producer and is very often operated at a loss.

Period 2 necessarily ends with the life of the building which occurs when obsolescence has progressed so far that the building is torn down to be replaced by a new structure. Because of the fact that when a building has arrived at the second period of its life and it is only a question of time when it will have to be torn down, its investment value declines very rapidly and is very often extinguished entirely. That is, whereas if a building is sold during the first period of its life, it will bring a price somewhere near its cost; if it is sold in the second period of its life, it will bring a very much smaller price and very often will not be considered as adding any value whatever to the land on which it stands. As a consequence, while a building in the second period of its life may for a time under favorable conditions continue to be operated at a small margin of profit, obsolescence will have largely or wholly destroyed its sale value.

A leading building manager in New York states that all thirty-year-old buildings south of Chambers Street are now non-producers of adequate return and, therefore, economically obsolete. He believes that the safe conservative estimate of life is about twenty-five years. He also feels that depreciation is likely to be faster in the future than in the past. Changes in construction methods, in lighting, and in artificial ventilation are very likely to occur, also hastening obsolescence. Ten years is all we can safely see into the future.

In this connection it is interesting to go back to the study made by Mr. Shultz and consider the ratio between the values of land and building for structures of different ages.

This has been done by taking the ratio between land and building for all the buildings reporting and grouping them by ages to obtain five-year averages as previously explained. The averages thus obtained are indicated on [Graph No. 21]. On this chart the two curves marked "AA" represent the increasing ratio between land and building as the age of the building increases. The solid line represents the actual five-year averages, and the dotted line a theoretical curve drawn through these averages. From these curves it will be seen that during the early years of its life, the value of the average building is equal to the value of the land on which it stands. This ratio, however, increases more and more rapidly until at the age of fifty years, the value of the land has become six times the value of the building. In other words, if a lot now valued at \$100,000, for instance, requires as an adequate improvement a building costing \$100,000 or more, then after a period of fifty years when the value of this lot has become approxi-



mately \$500,000, any improvement thereon to be adequate must have a value of \$500,000.

The increase in land value also materially affects the investment value of the building situated thereon. At the time a building is built, it must earn a return not only on the investment in the building, but also upon the value of the land. This is true even if the land is not owned by the same owners as the building, because of the fact that all ground leases provide that the lessee must pay the taxes. As the value of the land increases, the amount of taxes increases in proportion. It follows, therefore, that as the value of the land increases through the growth of a city, the amount of capital on which the building must earn a proper return continuously increases, with the result that either the gross income of the building must increase correspondingly or the net return of the property will decrease, so that the building will, in the course of time, lose a great part of its value as an investment. On [Graph No. 21], the dotted line "BB" indicates the decreasing percentage of return which the same amount of income will yield on the increasing value of the investment in building and land. Starting at $7\frac{1}{2}\%$ for a five year old building, the percentage of return drops to less than 2% for the fifty year old building.

As business increases, not in arithmetical proportion to population but according to a power of the increase in population, the inten-

sity of business is greater in the larger cities. This causes a more rapid rise in land values of those cities and consequently quicker obsolescence of their office buildings.

The following is an extract from a letter of the Hon. Lawson Purdy, former President of the Board of Taxes and Assessment of the City of New York:

"The most important office buildings are in the Borough of Manhattan in the city of New York. Changes have been so rapid that frequently a building ceased to have any value before it had suffered any depreciation from age that was visible or ascertainable. . . . A building is worth what it will earn, though ordinarily it cannot be worth more than the cost of reproduction new. *Some buildings in Manhattan become obsolete in five years and cumber the ground.*"

A second method of studying the effect of increasing land values is to take the assessed values of the several properties over a period of years and compute the percentage of increase or decrease per year. Such a computation is shown in [the tabulation given below]. On this table are given the five-year averages for ninety-one buildings that gave their tax figures over a period of time sufficient to be indicative. The table gives averages of the age of each group; the rate of increase in tax value of the properties that increased in each group; the decrease in tax values of the properties that decreased in each group; the ratio between the value of the land and the building; and the gross and net incomes and expenses. It also gives the average of these several items for all the buildings.

CHANGE IN LAND VALUES, 91 BUILDINGS

1	2	3	4	5	6	7
33.8	9.3	3.8	2.97	12.7	4.4	8.3
28.0	10.4	3.3	1.51	15.1	4.5	10.6
23.1	12.8	—	0.90	15.4	5.5	9.9
18.1	9.5	1.35	1.79	15.6	6.4	9.2
12.3	7.0	3.4	1.14	16.0	6.6	9.4
8.9	9.8	0.4	0.69	15.3	6.3	8.0
4.5	20.2	—	0.19	17.9	8.1	9.8
<u>19.0</u>	<u>9.6</u>	<u>2.77</u>	<u>1.35</u>	<u>15.30</u>	<u>5.72</u>	<u>9.58</u>

Column 1. Average age of group of buildings.

Column 2. Rate of increase in land values.

Column 3. Rate of decrease in land values.

Column 4. Ratio of land to building values.

Column 5. Percentage gross income.

Column 6. Percentage net income.

Column 7. Percentage expenses.

It will be seen that the average increase in the value of the land is 9.6 per cent per year. In other words, a piece of land increasing in

value in the business district of our larger cities doubles its value in about ten years. This corresponds exactly to the results obtained on [the preceding graph], which showed an increase of five to six times in fifty years. In obtaining this average, the rates of increase in land values of properties showing an increase at any period of their history have been included for that period during which the value of their land was increasing. For many of these buildings, the increase in value later ceased and in some cases was followed by a decline. The average rate of decline as indicated by this table is 2.77 per annum or less than one-third the rate of the increase. The table also indicates that whereas the very newest buildings had a building-value five times that of the land, the average for the older buildings was a building value only one-third that of the land. The table also indicates the decline in the gross and net incomes with the age of the buildings [and] thus corroborates the conclusions of [the graph].

* * * * *

. . . . the newer type of building will be built upon two principal ideas. First, a design efficient in layout and economical in operation; and second, it will be built to provide not only space in which tenants can exist, but to be an integral part in the functioning of those tenants.

Another method of allowing for obsolescence is stated in the following quotation from the article by Messrs. Keast and Randall in *The Architectural Record* for April, 1930:

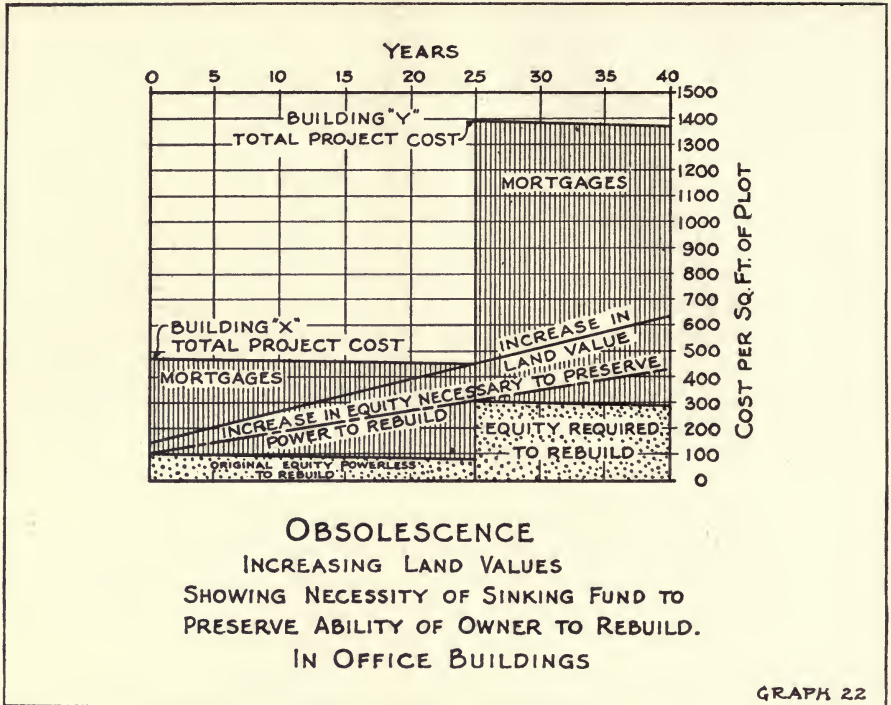
CASE 1. OBSOLESCENCE FOR INCREASING LAND VALUE

Consider first a development on \$150 land where the building has been designed in a ratio of about 1.4, or has a cost of \$215 per square foot of land. Carrying charges, etc., bring the total project cost or capitalization to about \$470 per square foot of plot.

Let it be assumed that this land in twenty-five years increases to 300% of its initial value, an increase which is in line with many that have occurred in our typical cities.

At the end of this time, with land at \$450 per square foot, the building is in inadequate relationship to land value; and due to increased taxes and operating expense, coupled with rentals well below those obtainable with new buildings on land of this value (due to the age of the building), the margin of profit is wiped out and an actual annual deficit develops. The building is probably in a fair state of preservation but its economic life is ended.

The owner's initial equity, 22% of the total project cost, or \$104 per square foot of plot, is reduced to \$84. The building costing about \$215, plus \$105 carrying charges is now valueless, resulting in a loss



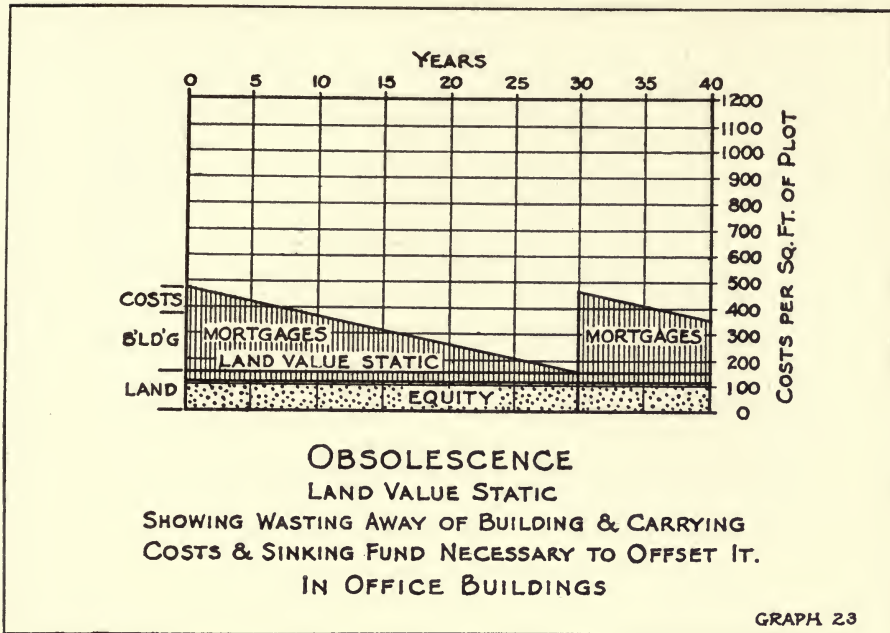
of \$320 per square foot of plot. The increase in land value has almost offset this by its enhancement of \$300 per square foot of plot, so that a loss of only \$20 per square foot of plot has occurred.

However the status of the owner is not very favorable, since a project cost of about \$1,398 per square foot of plot is required on the new land value of \$450, to bring in a proper return. The equity balance of \$84 per square foot of plot is only about 6% of the new project cost in place of the 22% needed. The deficiency in equity is thus about \$224, which is a more severe requirement to make up than is the loss in equity of \$20. To raise this sum in 25 years, compounded at 5% interest, would require a sinking fund of \$4.47 per year or approximately 1.4% on the cost of the building with carrying charges totaling \$320 — the value on which the replacement is based.

Graph [No. 22] illustrates the necessity of preserving the ability to rebuild on land increasing in value.

CASE 2. STATIC LAND

In the case of static land value, the amount required to be set aside to preserve the owner's equity intact is merely equal to the building-and-carrying costs which have wasted away. This equity will suffice



to rebuild as before, since the land value is unchanged and the same project cost required. The average life of a building under these conditions may well be taken at 30 years.

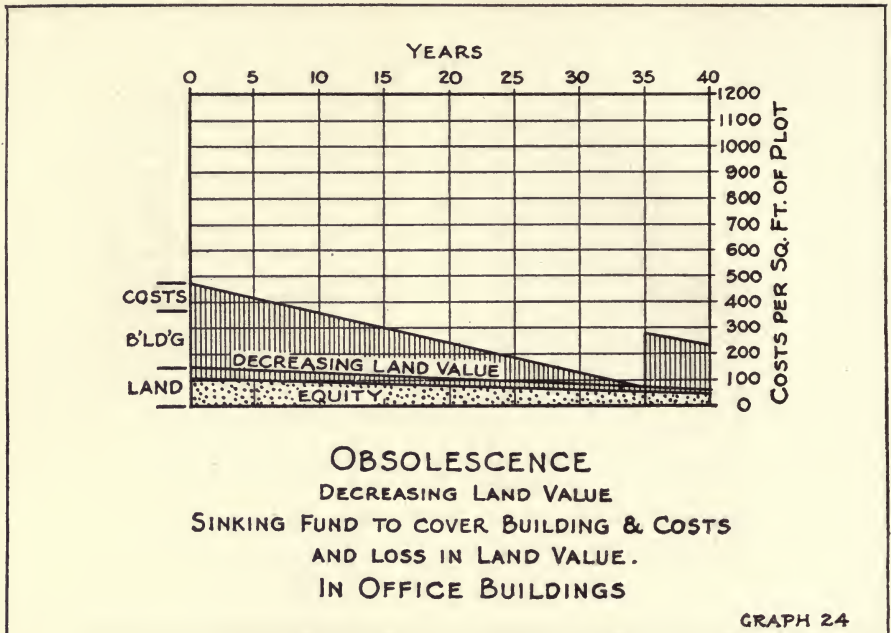
The original building and costs amounting to \$320 per square foot of plot are therefore to be replaced in 30 years. This requires an annual sinking fund of \$4.59, or 1.43% on the value wasted away.

Such a sum will both protect the owner's equity and enable him to rebuild since the requirements for both are the same in this case [see Graph No. 23].

CASE 3. DECREASING LAND VALUE

On decreasing land value not only must the cost of building and carrying charges be raised, but also the amount of decrease in the land value, which has also wasted away.

On the basis of the same initial costs, let us assume that the land has decreased 50% in value to \$75 per square foot of plot in a 35-year period (which may reasonably be taken as the building life under these conditions). This decrease of \$75 in value coupled with the building and other costs of \$320, make a total of \$395 which has wasted away. This sum must therefore be raised to preserve the equity value; it requires a sinking fund of about \$4.17 which is approximately 1.3% on the original investment less the land value.



More severe cases have occurred than that indicated for rising land value. It is therefore believed that an allowance of $1\frac{1}{2}\%$ per year based on building and carrying costs, or total investment less land value should be allowed for obsolescence, regardless of whether land value is increasing, decreasing, or remaining static. This should be placed in a sinking fund accumulating at 5% or more.

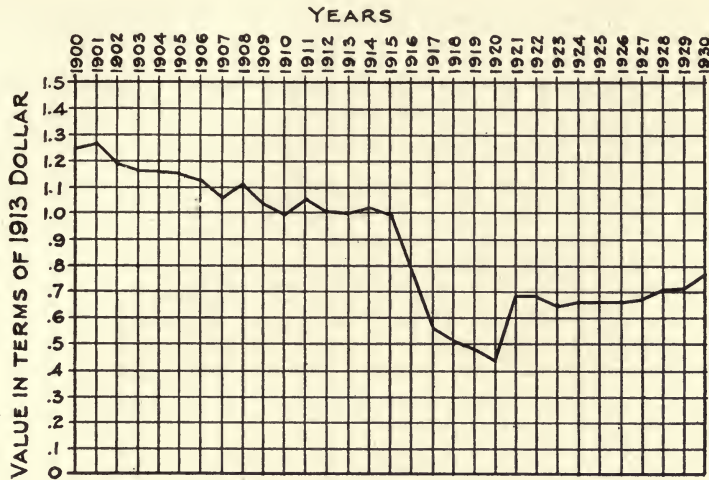
Note that buildings in *uneconomic ratio* to their land value are subject to increased obsolescence from inadequacy, and therefore require greater sinking fund allowance than correctly proportioned buildings, due to their shorter span of useful life [see Graph No. 24].

RENTAL RATES DECLINE WITH OBSOLESCENCE

A study of a number of buildings shows that the new building may obtain the maximum to be expected from the land value; thereupon, for the first period of its life, rents may increase almost in proportion to the increase in the land; during the second period they fail more and more to keep pace, and in the end may actually have to be reduced to hold the tenants.

On decreasing land values rents decrease, with obsolescence, more rapidly than the land. Here vacancy problems as well as change of use must be included in the study.

The complete study for the life of a building, based on that of its neighbors, must be counted in estimating for this final decline.



BUYING POWER OF THE DOLLAR
1900-1930
BASED ON THE 1913 DOLLAR VALUE
FOR OFFICE BUILDINGS

GRAPH 25

BUILDING CYCLES OVER A PERIOD OF TIME

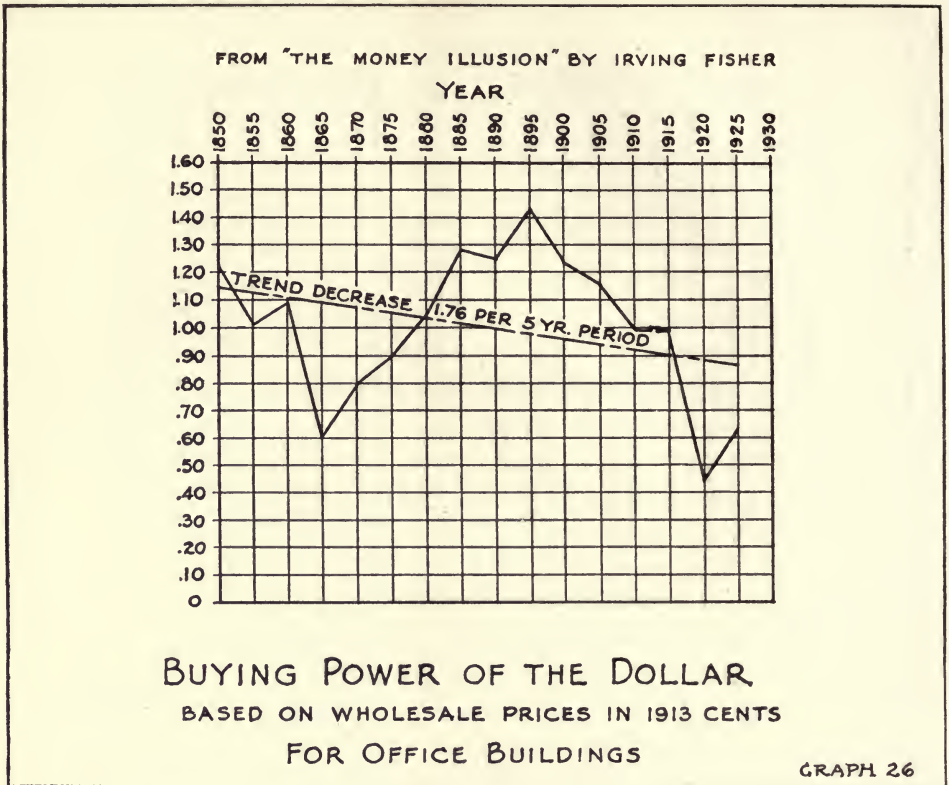
On any site, over a long period of time, the land value appears to follow a cycle. First it may have increased, then remained static, then decreased. This cycle has not affected all properties, but can be seen in full in certain sections of the city, and may be expected anywhere. (The shrinking dollar may mean that many properties apparently static, or slightly on the increase, are really on the decline. See Graphs Nos. 25 and 26.)

This shift of value may call for different *types* of buildings at its various stages, to satisfy the potential earnings: *e.g.*, first a dwelling, then an apartment or store, then a larger apartment, store, or office building, and then — with the decreasing value — perhaps a loft structure.

To secure a reasonable return on a site, it is well to prevision the entire *series* of buildings on it.

THE MINIMUM BUILDING FOR THE AVERAGE FUTURE INCOME

In the face of probable changes in land value, taxes, and other costs, it becomes necessary to relate the minimum building as calculated for the present to that for the normal period of future life.



This building must be so proportioned as to afford the maximum gains by incurring the minimum losses. An *average* minimum building can thus be deduced.

More exactly stated, in the determination of the "average building" present gains *plus compound interest* must balance future losses, if land value is rising; and present losses must be balanced by future gains *discounted* in the case of falling land value.

VACANCIES

Graph No. 8 was prepared from all available statistics in one of the largest and most typical American cities. Curves that have been observed for other typical larger cities are quite similar. It is interesting to note that whereas in 1924 there were about 16 per cent vacancies, by early 1930 these had risen to about 19 per cent. The total occupied space increased nearly 50 per cent during this period, but on the other hand the vacant space actually doubled during the same period. In other words,

the supply has been increasing at least half as fast again as the demand. Obviously, this means that whereas a particular new building may have a very small percentage of vacancies, it is unsafe to count too strongly on this eventuality, since with such competition even the best of buildings is likely to become obsolete in a very short time, and therefore adequate allowance for vacancy caused by obsolescence must be provided for. One of the best-known building managers in New York states that it is customary to allow for an annual vacancy of about 10 per cent, but it was found to be much safer to use nearer 20 per cent in a problematical district. He states that an office building often takes as much as two or three years to fill up to the ordinary 90 per cent occupancy. However, if the project is particularly good, the building should reach substantially a 90 per cent occupancy within a year.

With regard to high-grade apartment houses, a 10 per cent vacancy allowance is usual. However, this has increased somewhat for lower grades and for tenement houses.

Another high-grade apartment-house specialist states that after the first year, high-grade apartments should be 95 per cent to 96 per cent rented. However, of course, this would not apply to buildings erected in the wrong location. Another leading manager shows that the occupancy allowance for offices should be 90 per cent, for apartments 90 per cent for the first year, and for hotels 85 per cent or even lower.

APPENDIX X
APARTMENT HOUSE STUDY ¹
ASSESSED VALUES AND TAXES

The assessed values of land and buildings and the taxes paid by each building included in this study were carefully plotted, averages were figured, and curves drawn. The tabulation shown on the following page gives the significant trends which were observed. Houses, classified according to number of families accommodated, tend to be located on land having definite relation to the cost of the building placed thereon.

* * * * *

From the tabulation which follows it is evident that the three-family house is frequently built on relatively cheap land. Four-, six-, eight-, ten-, twelve-, and fourteen-family houses tend to be located on land where the land cost is relatively much higher in proportion to the building cost. It is not until the twenty-two family house is reached that the value of the structure again reaches a point five times the value of the land. From this point on there appears to be a fairly consistent relationship between land and building value — both values increasing at steady rates but with the building values at a slightly higher rate than the land values. This is evident from the fact that the ratio between building and land values maintains a steady but slow growth above thirty families.

The tabulation given on page 133 is really worth very careful study for it brings together for the first time data of this kind, and while there is inevitably a spread in land and building values for houses of different sizes, nevertheless the curves from which these figures were taken were very carefully plotted on the basis of the data reported and they may be accepted as having a high degree of accuracy. One caution only may be sounded, and that is that the values given are “assessed” values and therefore differ from the “true” value to the extent that assessed values generally depart from true value standards.

¹ Prepared by Mr. Wayne D. Heydecker in 1926 for the Westchester County Planning Federation.

No. of FAMILIES	LAND		BUILDING		TAX CON- TRIBUTION PER FAMILY	RATIO OF BUILDING COST TO LAND COST
	Cost of Purchase	Cost per Family	Cost of Construction	Cost per Family		
3	\$2500	\$833	\$15,000	\$5000	\$170	6.0
4	5400	1350	20,000	5000	200	3.7
6	12,000	2000	30,000	5000	185	2.5
8	16,000	2000	40,000	5000	175	2.5
10	18,000	1800	50,000	5000	165	2.7
12	20,000	1666	60,000	5000	160	3.0
14	21,000	1500	70,000	5000	157	3.3
16	21,500	1343	80,000	5000	155	3.7
18	22,000	1222	90,000	5000	153	4.0
22	23,000	1045	110,000	5000	150	4.7
26	24,000	925	126,000	4846	147	5.2
30	25,000	833	142,000	4733	145	5.6
40	28,000	700	175,000	4375	145	6.2
50	31,000	620	205,000	4100	145	6.6
60	35,000	583	240,000	4000	145	6.8
70	39,000	557	280,000	4000	143	7.1
80	44,000	550	330,000	4125	140	7.5
90	49,000	544	390,000	4333	136	7.9
100	52,000	520	450,000	4500	130	8.6
110	60,000	545	520,000	4727	120	8.6

Boiled down to common everyday language, this tabulation indicates that multi-family houses from four to twenty families have disproportionately great land costs and are therefore less economic than the three-family houses or those housing twenty-two or more families. This is a somewhat disconcerting discovery in view of the fact that for years in other near-by territories, notably Brooklyn, Queens, and northern New Jersey, the tendency has been to build multi-family houses housing less than ten families. Students of housing generally had come to regard this type as a practical, profitable type of construction. Westchester figures seem to indicate that if the community wishes to swing to apartment houses it had better swing to the larger type. The Westchester figures also indicate the relative undesirability on economic grounds of the four-, six-, eight-, ten-, twelve-, and fourteen-family house.

TABLE
RECENT APARTMENTS

NAME OF APARTMENT BUILDING	NUMBER OF APART- MENTS	TOTAL NUMBER PEOPLE IN BUILDING	AVERAGE PER CENT OCCU- PANCY	AVERAGE NUMBER ROOMS PER APARTMENT	AVERAGE NUMBER PERSONS PER APARTMENT
1. Locust Court	65	147	95.3	4	2.37
2. Locust Arms	60	134	90	4	2.48
3. Royal Arms	18	42	77.2	5	3
4. 11 Locust Avenue . .	9	26	100	6	3
5. Sun Haven	45	72	68.8	3	2.32
6. Stonlea	24	47	75	3.6	2.61
7. Webster Crest	—	—	—	—	—
8. Trident	18	45	77.7	5	3.2
9. Chapman	31	93	100	3.4	3
10. Odell Court	48	91	82.2	3	2.33
11. Beaufort Gardens . .	37	67	89.1	2.73	2.03
12. 26 Boulevard	7	25	100	3.6	3.5
13. Remington Arms . . .	26	78	96	4	3.12
14. Jackson Arms	37	102	91.8	3.24	3
15. Mayflower Court . . .	9	27	88.8	3.4	3.4
16. Webster Gardens . . .	38	63	84.2	3	1.96
17. Pine Brook Lodge . .	—	—	—	—	—
18. Franklin Hall	39	74	82	3.7	2.31
19. Bonefoy Court	26	67	92	3.8	2.79
20. May & Sickles	20	43	90	3.1	2.38
21. Beechmont Towers . .	69	164	59.4	3.9	4
22. Oakhurst Gardens . .	53	66	49	4.4	2.53
23. Carlton Court	72	120	41.6	4.1	4
24. Mayflower Court . . .	37	67	86.4	2.9	2.09
Total	788	1660	1816.5	82.87	61.42
Average	36	75	82.5%	3.76	2.8

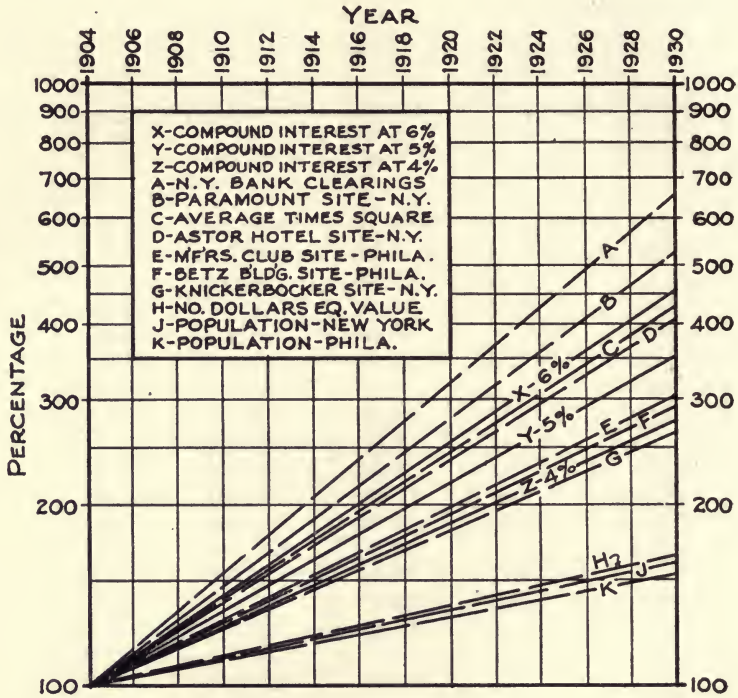
X

Data from Mr. Paul A. Bankson,
Civil Engineer, New Rochelle, N. Y.

IN NEW ROCHELLE

AVERAGE NUMBER SQUARE FEET OF LAND PER FAMILY	PER CENT LOT OCCUPIED	AVERAGE NUMBER SQUARE FEET BUILDING AREA PER FAMILY	AVERAGE MONTHLY RENT PER ROOM	ASSESSED VALUATION OF BUILDING	ASSESSED VALUATION OF LAND	STORIES HIGH
476	35.7	1020	\$32.50	\$376,784	\$48,475	6
515	35.7	1104	37.50	376,752	47,575	6
*1,472	*25.5	1125	33.00	139,400	32,185	3
555	60.8	1351	16.66	42,135	15,060	4
519	35.0	728	25.00	182,474	19,695	4
604	34.5	834	25.00	121,269	9,390	4
—	34.9	—	—	245,790	25,570	4
976	37.9	1467	24.50	109,324	15,300	4
250	57.4	864	30.00	154,603	12,375	6
218	63.8	837	30.00	250,140	16,740	6
608	25.0	764	38.00	180,045	17,400	5
*2,766	*10.1	839	30.00	35,900	7,045	3
387	62.3	971	32.00	148,785	9,465	4
274	67.2	737	23.00	157,050	8,850	4
617	30.0	740	25.00	37,539	2,550	4
406	24.6	401	37.00	89,995	12,870	4
—	20.8	—	—	240,115	26,230	4
315	73.3	925	25.00	211,609	12,800	4
288	63.0	910	30.00	133,705	14,500	5
225	76.0	684	25.00	81,805	5,000	4
398	48.9	1168	30.00	474,575	39,060	6
457	54.5	1493	38.00	515,905	21,780	6
533	45.8	1315	35.00	551,908	23,170	6
789	19.1	755	30.00	175,598	7,930	5
13,648	1,041.8	21,032	\$652.16	\$5,033,205	\$ 451,015	111
4,238*	35.6*					
9,410	1,006.2					
470	41.9	956	\$ 29.64	\$ 209,716	\$ 18,792	4.6

* Additional buildings contemplated.



TREND OF INCREASE IN LAND VALUES

TIMES SQUARE NEW YORK & BROAD ST. PHILA.

SHOWING COMPARISON WITH LINE OF VARYING DOLLAR VALUE,
 COMPOUND INTEREST 4%, 5% AND 6%, POPULATION INCREASE
 IN NEW YORK AND PHILADELPHIA AND NEW YORK
 BANK CLEARINGS

FOR OFFICE BUILDINGS

GRAPH-27

See Explanatory Note on Page 181.

APPENDIX XI

DISCUSSION OF THE APARTMENT HOUSE GRAPHS ¹

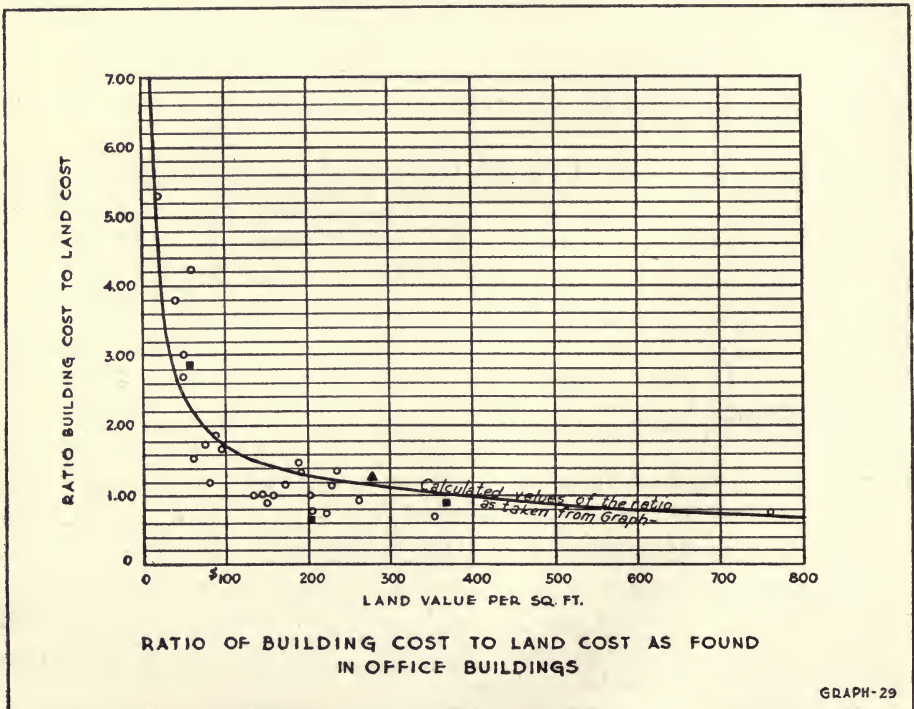
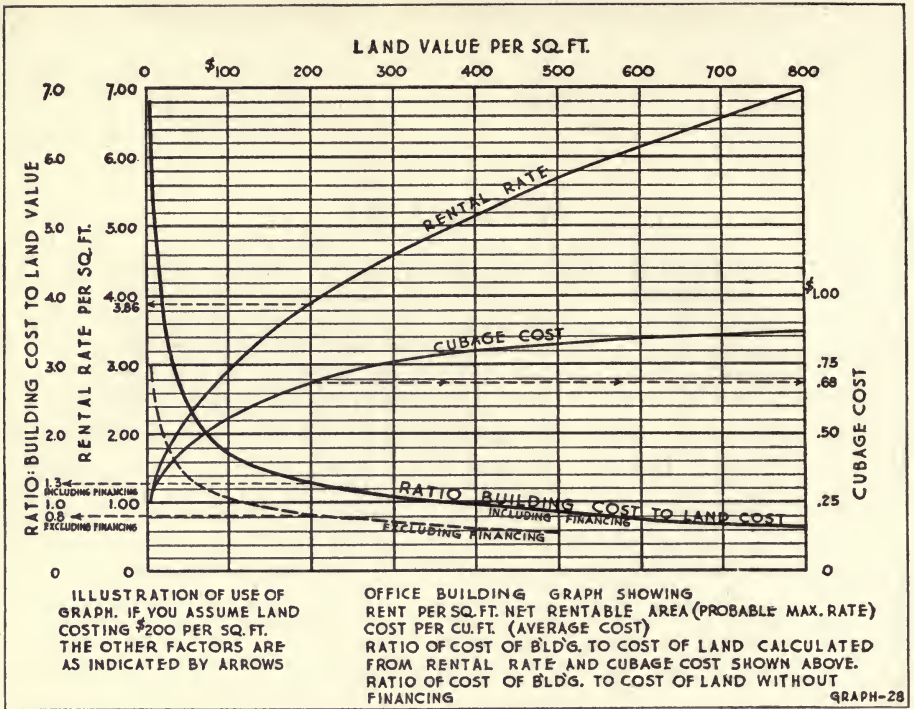
IN the analysis of the conditions of office buildings and other forms of commercial buildings, study had been directed to the ratio or the relationship that prevails between *land cost*, or land value, and the *cost of building* that was erected thereon, and also to the other items of the capital, capitalization, income, and expense accounts in order to ascertain what the fundamental and basic relationships were, if any could be found.

A similar study of these factors in apartment houses was attempted on an empiric basis, in the endeavor to discover the proportions and the values of some of the outstanding factors as they were actually found to exist in a number of cases. Unlike the study that was made by Keast and Randall on Office Buildings, this Apartment House Study did not and could not include, in the time available, the full re-study of the balance and the general relationships of the elements in the capital account, which must exist in order that the project should be profitable and successful in that it would earn a given sum on the equity invested by the owners.

In any interpretation of the following graphs and the data on which they are based, it is necessary to realize fully that these plottings are based on the results that have been gathered from definite buildings, and the conditions that have been found. It is believed that the data that have been given in confidence by many owners, agents, and managers are authentic. The data as collected have been compiled without any attempt to mold them toward any preconceived theory, and they are presented exactly as they came.

It should not be assumed that the ratio of building cost to land value, or the amount of net rentable areas that were built on a foot of plot area, or the volume of the buildings per foot of plot, etc., are of necessity right and correct. (See Graph No. 63.) Probably in many cases they are not, and they may represent errors. However, it should be remembered that in practically all cases the result was the work of owners, operators, and

¹This chapter was prepared by Mr. A. B. Randall partly in collaboration with Mr. Ford but was not entirely completed until after Mr. Ford's death.

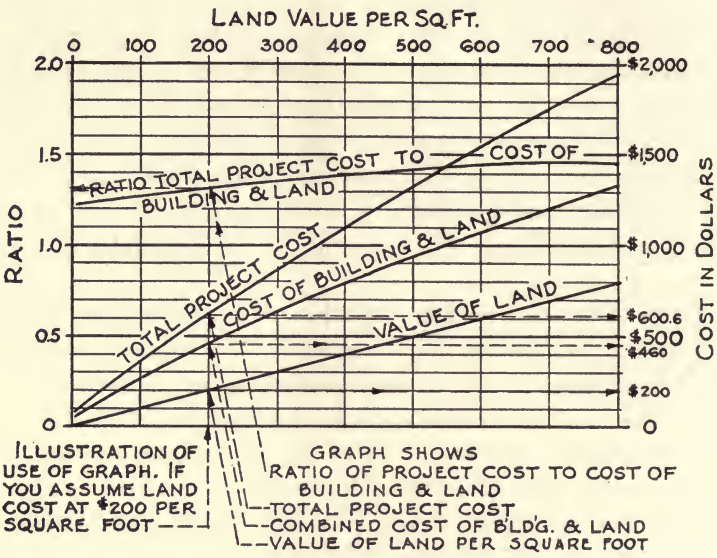


rental managers who were familiar with their business, and further that, as the majority of these projects were not completely financed by their owners, there was the additional advantage that the project was revised and amended to meet with the ideas and the best advices of the lending institutions which aided in the financing.

As a later study it is hoped that, based on building costs, land values (using varying ranges), other costs of development, carrying charges during construction, initial vacancy costs, financing fees, and the like, and considering the rentals that may be indicated in varying types of houses on the varying land values, as well as the items of expense that are found, an economic ratio or relationship between building cost and land cost may be deduced, as well as an evaluation of the various other factors. However, in the present case we must confine the discussion to the data that have been collected, and the trends that are observed from their compilation and plotting in the graphs. (See Graph No. 63.)

At the outset of the apartment house study, there was no doubt but that if the data were plotted on the basis of land value, the results would be as harmonious as in the case of similar data collected on office buildings. The value of land, except for speculation and undue optimism of future possibilities, is closely related to its earning capacity. This is in turn dependent upon the market conditions and the rate at which new space is taken up successfully. In addition to this the net earnings are of course dependent on the difference between the annual income and the annual expense. These depend on the rentals again, and on the operating, carrying, and interest charges, as well as on real estate taxes, depreciation, etc. The whole matter is a closely knit economic circle of interdependent factors, in which the land value or its cost is one of the basic elements.

There are cases where promoters, or sometimes owners, receive and should receive fees for the conception and the management of the project in its initial stages. These may be charged in with the other elements of legitimate capital cost. In other cases they are included in the project in just the same degree, but may take the form of an enhancement of value of the land. In other words, the land may have a market value that is at the time below the value that might be deduced on the basis of a particular project and its successful promotion, which is possible when the projectors of the development are able to anticipate a demand that has not yet come into being. This advance in the value of the land from



TOTAL INVESTMENT
FOR MINIMUM BUILDING INCLUDING
FINANCING
OFFICE BUILDINGS

a low value to a higher value is a form of wealth that is theirs by discovery.

There are other cases where, based on the opinions of others as reflected in asking prices, recorded sales, etc., the land costs are considerably above any value that can be warranted or sustained on the basis of the potential earnings of the site if developed to the fullest extent that would be justified by the market and the amount of space that can be added to the existing amount successfully rented. In such cases, if the size of the building is calculated in accordance with the value of the land at the price asked, it is seen that if a building of sufficient size is planned, it will be beyond reason and will therefore show the fallacy of the land valuation.

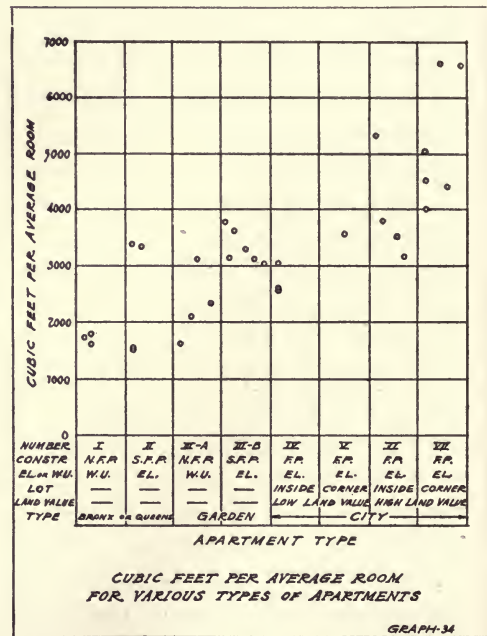
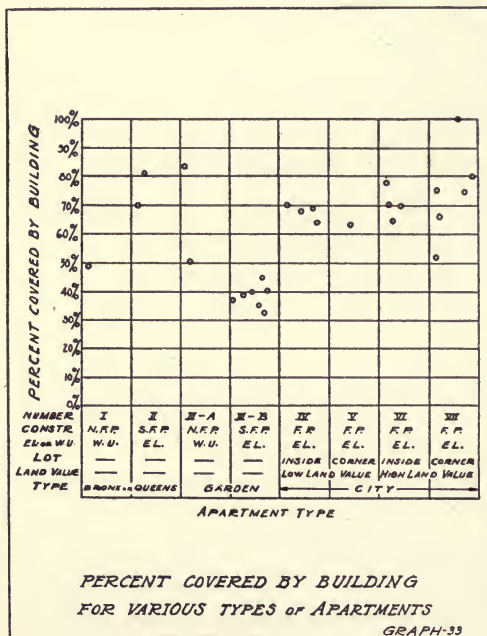
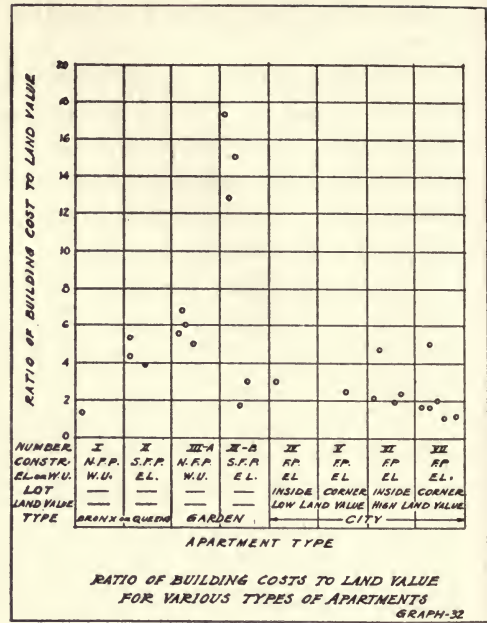
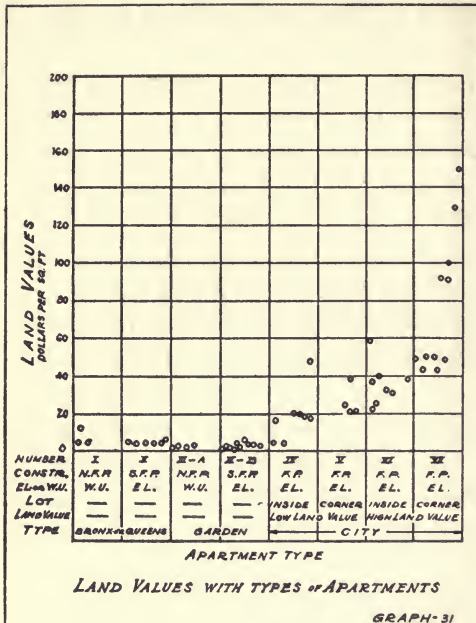
In other cases the land value is based on some valuation process considering its potential earnings at some future time that is relatively remote, and in this case the capitalization of this future value is not properly discounted back to a fair basis of present value.

With these facts in view, it is useful to know what is possible and being done on land of varying value so that some yardstick of comparison can be set up as a basis of judgment. Further, it should be realized that in many of the cases here given, the value of the land has increased since the project's inception and thus the buildings are somewhat inadequate, or are beginning to become so. It would therefore be reasonable to suppose that in many cases the ratios of building value to land value, the amounts of net rentable area, and the cubage that is constructed per square foot of plot area, are far more likely to be too small than too large.

The study was made on two general bases, namely on the basis of types and classes of apartments, and on the basis of land values. The types and classes of apartments were as outlined by Mr. John I. Conroy of Douglas L. Elliman and Company of New York City, specialist in apartment houses and their management.

Classes I and II are the non-central types such as are found in the Bronx and Queens, and usually cover a larger proportion of the plot than do the "garden apartments" and the "suburban apartments."

Class III is in general the garden type, although there may be some dispute as to the exact definition, in that those referred to in III-A usually cover a higher percentage of the plot than some would consider proper in the garden apartment, and might rather be defined as suburban apartments. As a general line of demarcation, the A Group of this class were the "walk-ups," and the B Group, the elevator apartments.



Classes IV and V are urban apartments on the less choice and less valuable sites and locations, and Classes VI and VII are on the best and most expensive land. The land values and the general rentals, costs, etc., of Classes IV and V exceed those of Classes I and II.

Apartment hotels were found in some cases, especially in Classes VI and VII, and in general were out of the usual trend of their Class. The building cost, rentals, and operating expense are usually somewhat above the averages.

It was most interesting to observe that the relationship between land values and these various Classes of houses was quite indicative of a general trend, and showed that the basis of land value was an excellent one for study, since not only were the other relationships in even better continuity on the land value basis, but also there was an elimination in many cases of any doubt that might arise in the assignment of a given project to its proper classification.

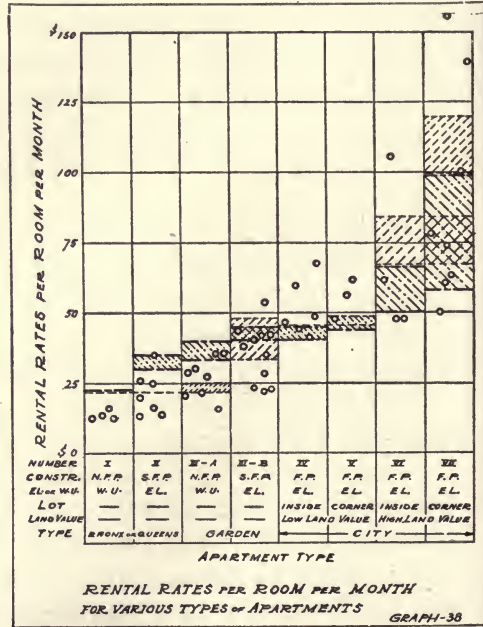
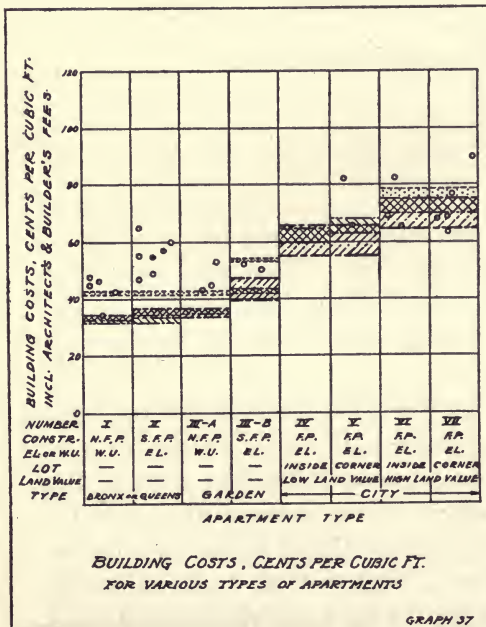
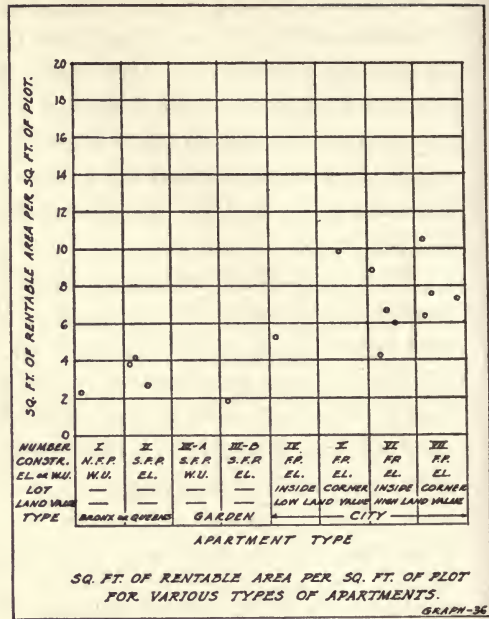
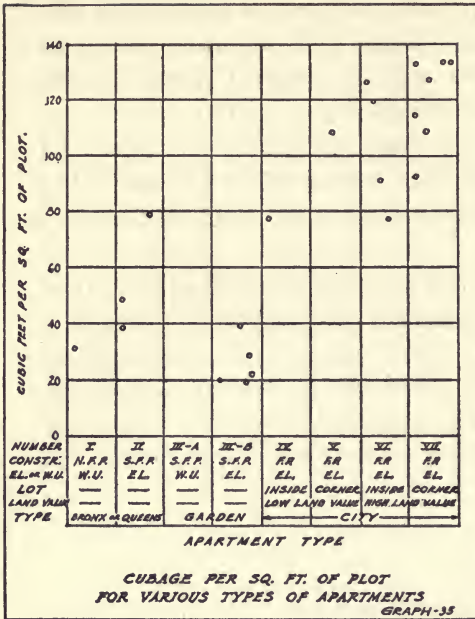
ANALYSIS OF APARTMENTS BY CLASSES

In the accompanying graphs, Nos. 31-42 inclusive, the meanings of the abbreviations are as follows :

FP — Fireproof	} as to construction
SFP — Semi-fireproof	
NFP — Non-fireproof	
EL — Elevator	} as to service
WU — Walk-up	

Graph No. 31 shows the apartments studied, plotted according to their Classes, and with the land values indicated. The continuity of the resultant trend and its agreement with most of the individual observations were very close, and better than those shown on the analysis of most of the other factors on this basis.

Graph No. 32 shows the ratio between the building costs and the land values as they were discovered. It is quite plain that in the cases of the lowest land values, the ratio was the highest, and in the cases of the highest land values the ratio was the lowest ; or in other words the ratio of building cost to land values is inversely proportional to the land values on varying land values. Its ranges were as high as 18 to 1 and 5 to 1 on the lowest land values, and became about $\frac{3}{4}$ to 1 on the highest land values.



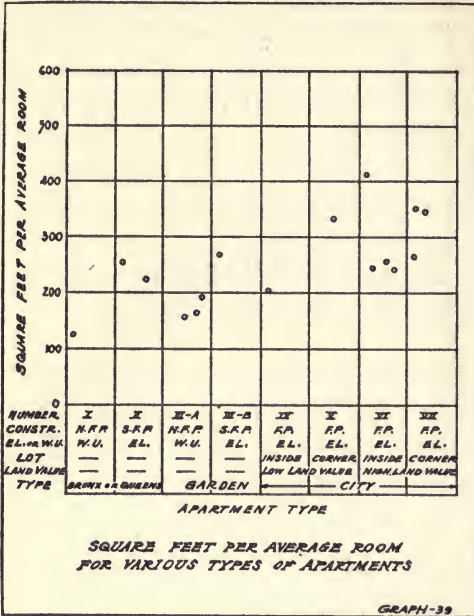
Coverage, or the percentage of the plot area that is covered by the building, is plotted on Graph No. 33. This shows what would be normally expected: that the coverage increases directly as the land value increases. The one structure that covers the maximum, 100 per cent, of its plot is in a city where there are no zoning laws and where the apartment is located on a very narrow lot on three street fronts. An apartment plotted in Class III-A was represented as a garden apartment, but this is probably a misnomer since any building covering greatly in excess of 50 per cent of its plot could not properly be represented as a garden apartment according to the common definition that seems fairly well accepted.

The number of cubic feet per room, as obtained from a division of the total cubic volume of the building by the number of rooms, shows a trend of increase between the classes, the largest being found on the most expensive land. In the same manner, the total net rentable area per square foot of plot area likewise increases as the value of the land increases. (See Graph No. 56.) This is obviously necessary because, although the rental rates increase as the buildings are located progressively on more valuable ground, this increase is insufficient to equalize the increased land cost, and it is therefore necessary that the owner provide more net rentable space on the more valuable plot to gain a proper return on his holdings and investment. Graphs Nos. 34, 35, and 36 respectively show these conditions.

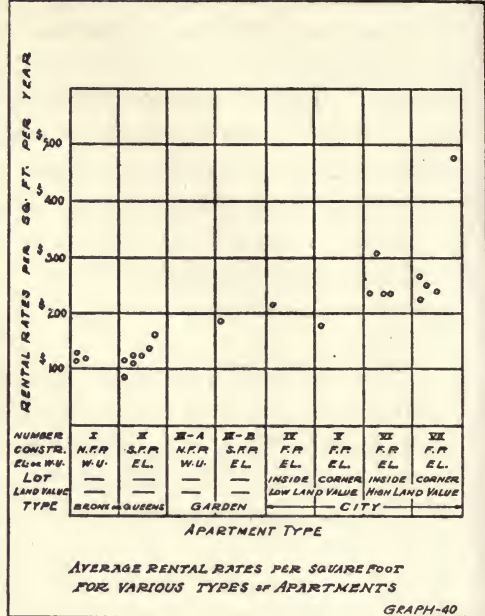
The costs of the buildings in cents per cubic foot are shown in Graph No. 37 by class of buildings. The plotted points are the results of data furnished on individual projects, while the bands or zones are the statements of various owners, operators, building managers, and lending institutions, each differently designated band representing an opinion from one specific source.

The rental rates in dollars per room per month with the various classes are shown in Graph No. 38, the form of presentation being the same as in the previous graph. The points show the individual buildings, and the bands show the opinions and the general experience as stated by certain experts. The three points that are considerably out of line in Classes VI and VII are apartment hotels.

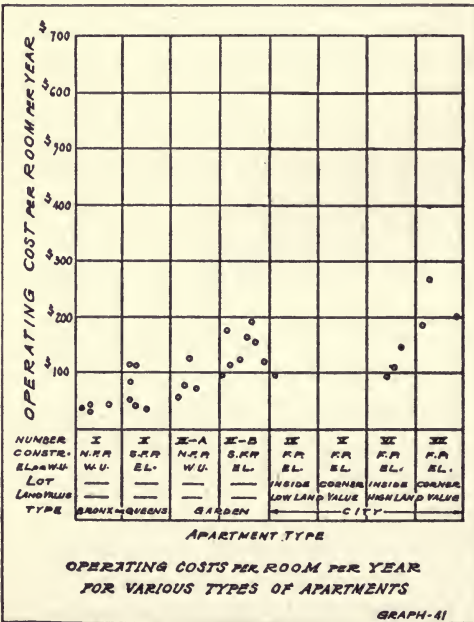
Study of Graph No. 39 shows that there is considerable divergence in the sizes of rooms, even when these are computed as an average, by dividing the total net rentable area in the building by the number of rooms. It is therefore felt that any "per room" basis of analysis is open to much



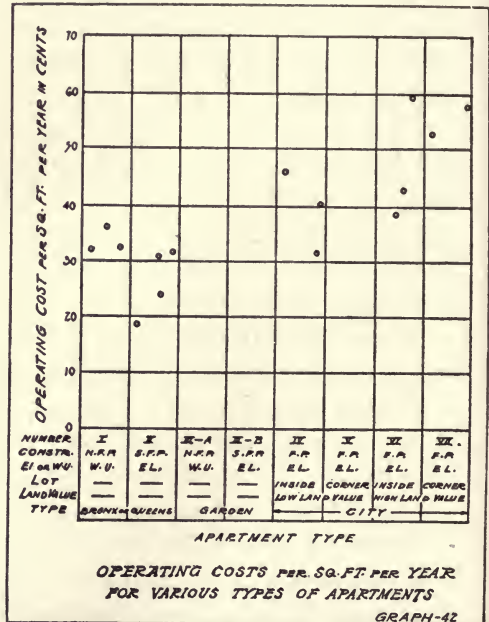
GRAPH-39



GRAPH-40



GRAPH-41



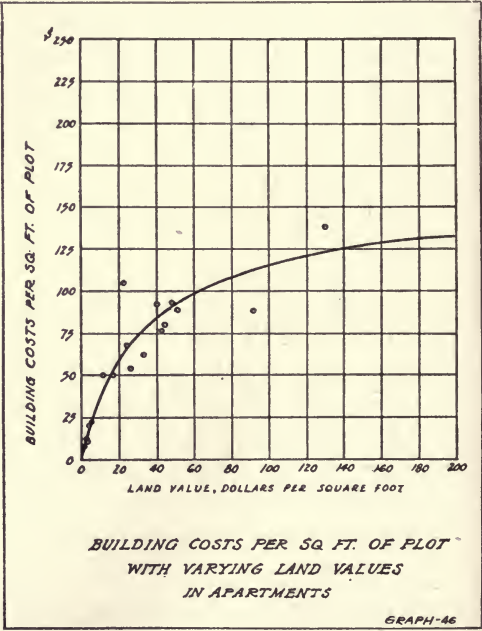
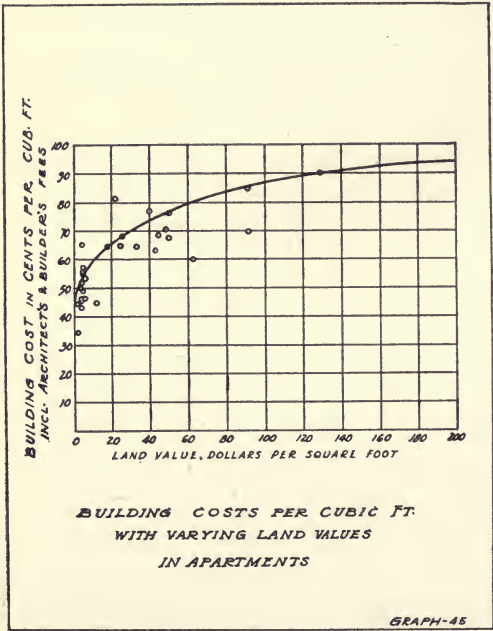
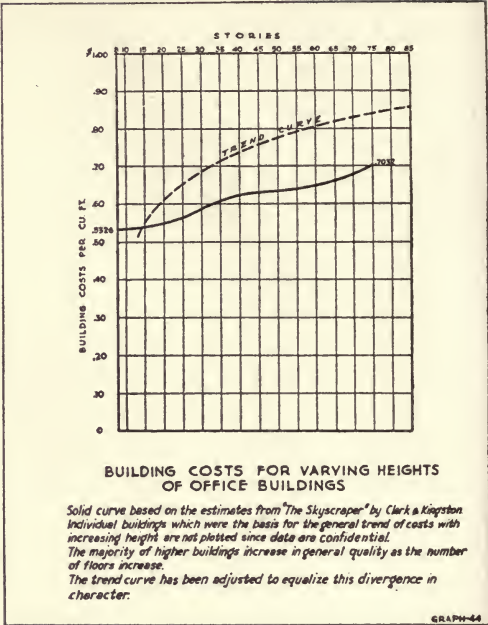
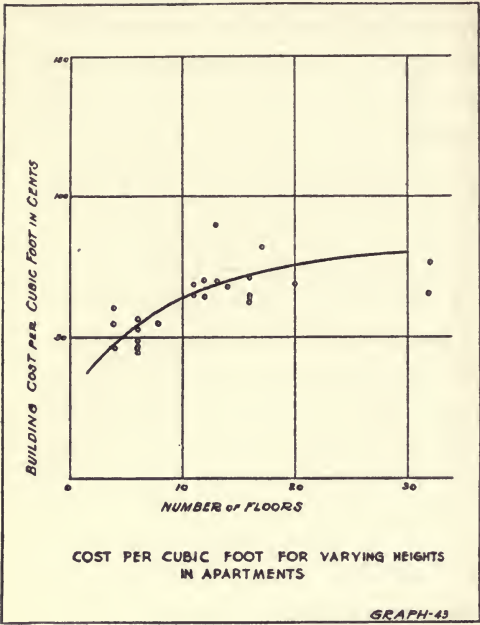
GRAPH-42

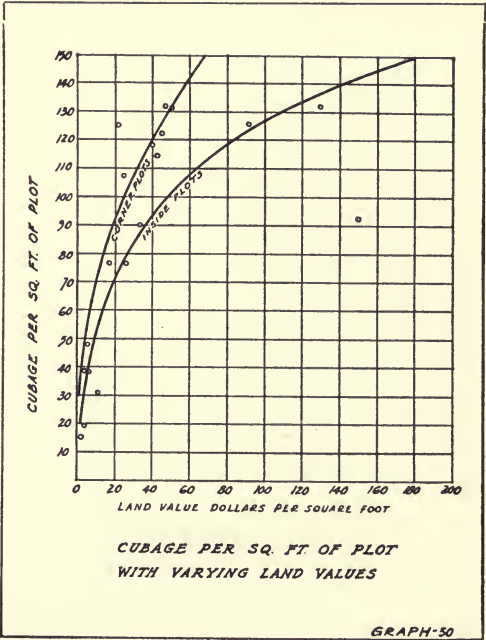
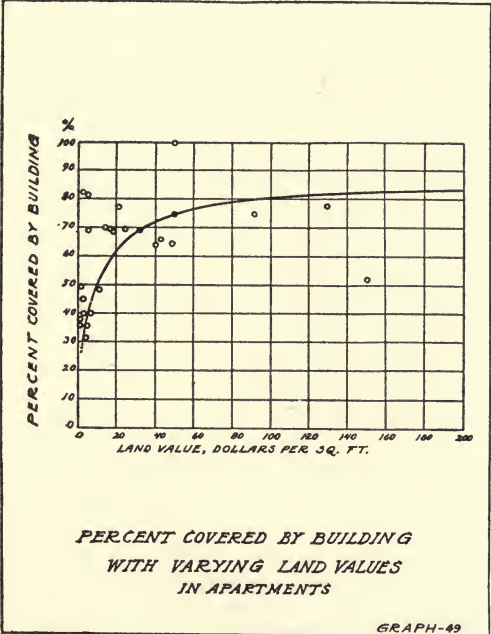
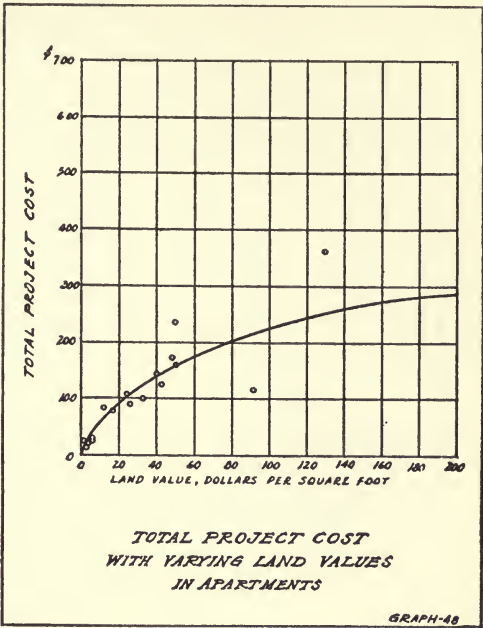
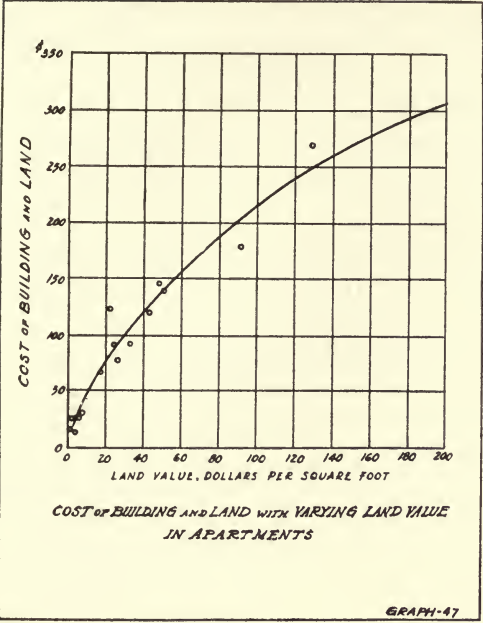
uncertainty, even in the same general classes of houses. Many of the rental agents, owners, and managers are now basing all their estimates of rental value on the square foot of net area, even though this is not announced nor published, and the price per room and per suite is the factor that is given out. Graph No. 40 shows that there is a very marked trend evident in these rates on the square foot basis as between the different classes of buildings. In Classes VI and VII there are two instances which are apartment hotels and so somewhat out of the general line.

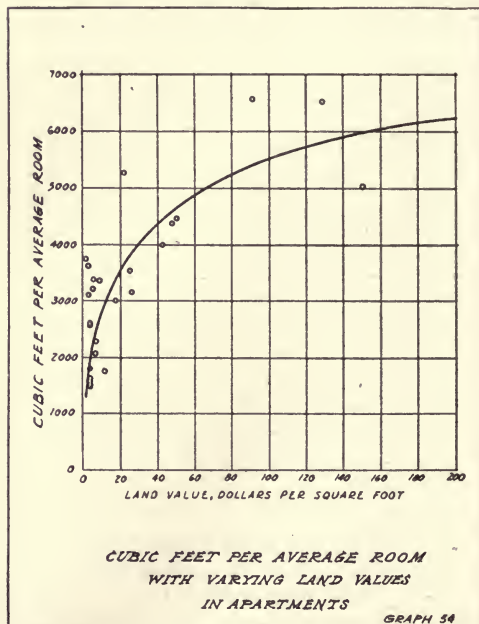
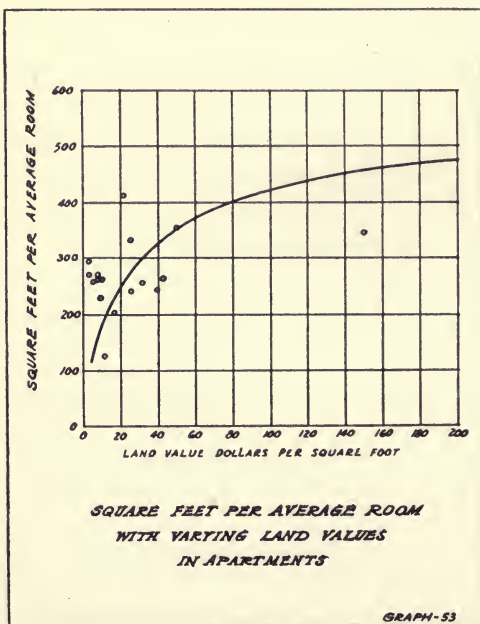
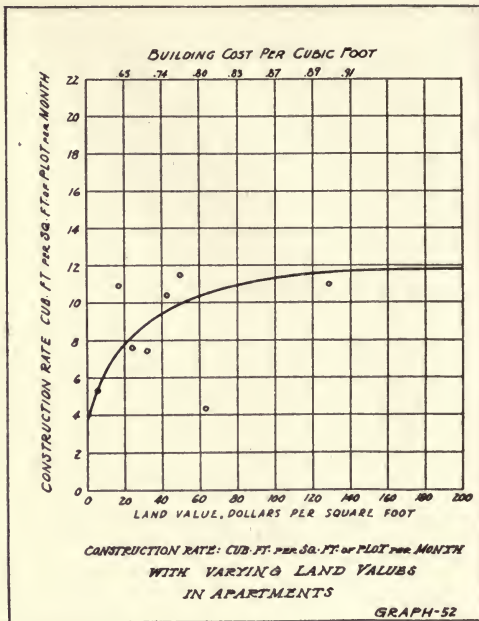
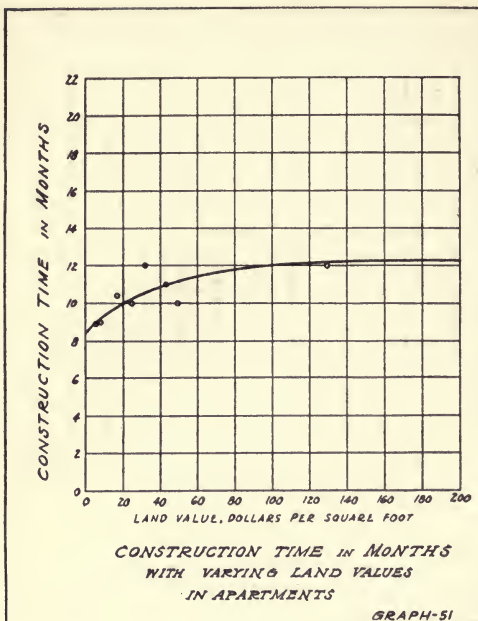
Graph No. 41 shows a fair trend in operation costs in the different classes, except that in Classes IV and V there was a reluctance on the part of managers to divulge their costs on a per room basis. There is often a fear on the part of managers that the information might be taken to the owners, with a comparison in results made by some other operating company, and the owner might be urged to change management companies on the basis of some promised economies, when the real difference would be due to some utterly different reason. However, better luck was had in the matter of these costs in these groups in Class IV on the basis of the square foot (see Graph No. 40), since more was told. In these cases the trends of this class and the others were reasonable, and it may be assumed that Class V would require slightly more expense than in Class IV, since a building on the corner is apt to be a little more pretentious in service given than those on the interior plots, and its heating bills would be naturally expected to be somewhat larger. Operating costs on these two bases are shown in Graphs Nos. 41 and 42.

Graph No. 39 shows the average room sizes that were deduced from the division of the total rentable areas in buildings by their number of rooms. The size of the average room increases with the value of the land.

There seems to be prevalent a most distorted idea as to the relative costs of the tall apartment as against the low building. Of course the classes of construction permitted in the low building and the degree of its safety and fireproofing cause a marked jump in cost at the level beyond which the building must be fireproof, but there seems to be little to warrant the belief that the cost per cubic foot is greatly increased by the height of the building. There is not the remotest reason seen why this cost should exceed \$1 per cubic foot unless very superfine and elaborate finish is required. In fact one of the tallest buildings on which data were obtained — thirty stories high — cost only \$.75 per cubic foot, and when in other cases lower buildings were found to cost \$.80 to \$.90







per cubic foot it was stated that a building that would have served the purpose just as well could have been built for about \$.70.

Although it was stated on excellent authority by a competent witness that several of our tallest office buildings could have been built for \$.70 to \$.75 per cubic foot (and one actually was), the rumor nevertheless persists that their cost is very much greater. Of course, the costs of a lot of marble, stained glass, and polished steel vaults may be included on this basis and lend color to the superstition, but surely all or most of this occurs in the lowest part of the structure, in fact the lowest six stories. If such costs were assigned to a six-story building the result would be even more distorted, and no one would dream of doing such a thing in the discussion of comparative building costs.

The cost of fireproof apartments, unless some very special conditions are involved, should not exceed \$.80 per cubic foot, and may be built for as low as \$.50 to \$.75, as may be seen from Graph No. 43. The cost of office buildings runs from about \$.53 to \$.70 or more per cubic foot according to height as shown on Graph No. 44.

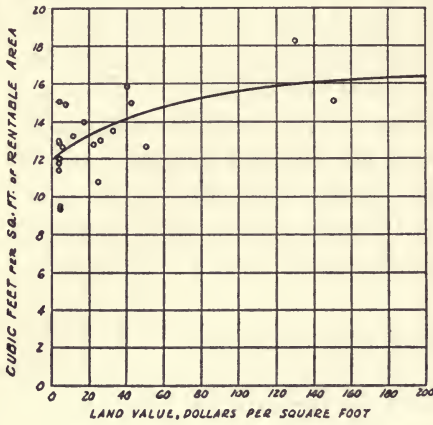
ANALYSIS OF MAJOR FACTORS OF CAPITAL COST

Building cost per cubic foot was studied in relation to land values in Graph No. 45 as it was studied in relation to types of apartments in Graph No. 37. It is noteworthy that on the more valuable land the building cost tends to increase, since the rental rates are much higher on such land, and a finer building is almost invariably erected.

Graph No. 46 shows the results of analysis of the total cost of the building per unit of plot area, and Graph No. 47 is but a step further on this line and shows the total cost of building plus land per square foot of plot area. Graph No. 48 shows the total project costs which should comprise land, building, carrying costs during construction, initial vacancy costs, contingencies, and miscellaneous charges like financing.

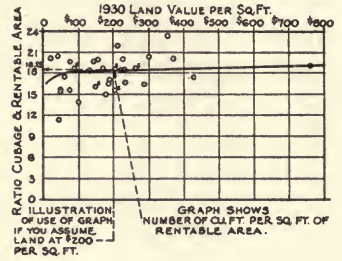
The time of construction has become a very vital element in the present-day building, and the costs of delay are felt in loss of potential income.

The larger buildings, as is shown in Graph No. 49 showing the percentage covered by the building, and in Graph No. 50 showing the cubic feet constructed per square foot of plot, are built on the more valuable plots, for the same reason as previously explained in the matter of rentable area per square foot of plot. In fact since the laws permit it, there is usually more cubage built per square foot of plot on the more valuable



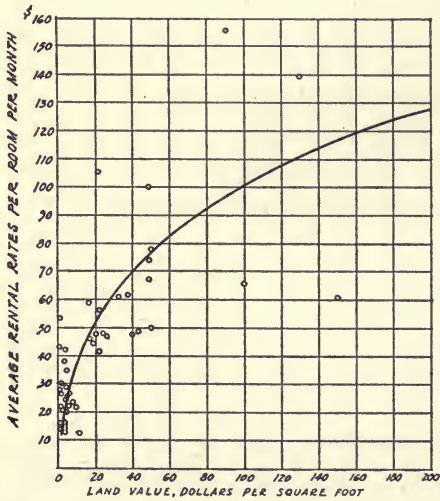
CUBIC FEET PER SQUARE FOOT OF RENTABLE AREA
WITH VARYING LAND VALUES
IN APARTMENTS

GRAPH-55



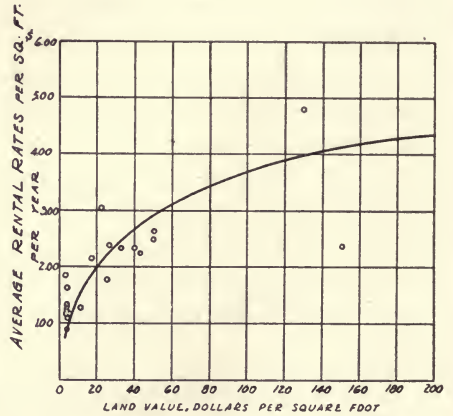
RATIO CUBAGE & RENTABLE AREA
IN OFFICE BUILDINGS

GRAPH-56



AVERAGE RENTAL RATES PER ROOM PER MONTH
WITH VARYING LAND VALUES
IN APARTMENTS

GRAPH-57



AVERAGE RENTAL RATES PER SQ. FOOT
WITH VARYING LAND VALUES
IN APARTMENTS

GRAPH-58

corner sites in New York. (Note that in Graph No. 50 this is evidenced by the split in the trend lines or the two trend lines, the higher for corner plots and the lower for inside plots.)

Graph No. 51 shows the time of construction in months for a number of buildings where accurate records could be obtained. This time includes the demolition of the old building on the site.

The following graph, No. 52, shows the construction rate in cubic feet constructed per month per square foot of plot area as based on the conditions found.

ANALYSIS OF MAJOR FACTORS OF THE INCOME ACCOUNT

In discussing the income accounts and the items that must be considered in arriving at the matter, it is necessary to take up the sizes of rooms, their areas, and the ceiling heights in order to arrive at the cubic feet that are constructed to produce the unit of the room.

The average number of square feet that were found in an ordinary room, as based on the total rentable area divided by the number of rooms, is shown in Graph No. 53. Graph No. 54 shows similarly the number of cubic feet per average room calculated from the total building cubage on the same basis. The number of cubic feet constructed to develop one square foot of net rentable area is shown in Graph No. 55.

It is reasonable to suppose that the sizes of the rooms would generally increase as the better grades of apartments are reached in the better classes and on the more expensive sites. The ceiling heights would also increase and thence the cubic feet per room. The results thus indicated show a range of between twelve and about sixteen cubic feet per square foot of net area developed. With increase in the size of rooms there is a slight tendency for the cubage to decrease, but this is usually offset by the tendency of the increased ceiling height to increase the cubage. The ratio of cubage and rentable area in office buildings is shown in Graph No. 56.

Rentals were studied in relation to the amounts on land of varying value, and it was found as would be expected that they would increase on the more valuable land (see Graph No. 12). If this were not so, then the land would not be logically appraised at its greater value, and further, if these rentals were not possible on the choicer and higher-priced land, then it would not be possible profitably to construct apartments on them.

Although the per room basis was not deemed the most desirable one

for proper comparison, data were obtainable on this basis from the majority of rental schedules, and the analysis on the square foot basis had to be made later. The results obtained on the per room per month and on the per square foot per year bases of rental are shown on Graphs Nos. 57 and 58.

The examples that are out of the general line are either apartment hotels or houses devoted exclusively to small suites of one and two rooms. The example on land valued at about \$150 per square foot is probably a case of a building that was built some time ago before the land reached any such high value. In general it is believed that at the present time and with the present conditions of building costs, operation costs, rentals, etc., land of this high value is not warranted in being used for apartment purposes and would be more profitably employed in some more commercial use.

Net usable area may be defined as that in the rooms, kitchens, foyers, private corridors, closets, and baths, and excluding the utility areas of the building and areas devoted to the service of all tenants and so not chargeable to any one tenant.

In the analysis of the apartment rental schedules available the majority were all on the per suite and per room basis, and only the exceptional manager or rental agent had the rates on the square foot basis. In arriving at this, the total rent roll of the house had to be computed and then the total net areas on the basis outlined. This was a tedious process, and so not as many houses could be calculated in the available time on the square foot basis as was possible on the per room basis. However the most interesting and indicative ones were selected for calculation, and the results when plotted show a fair and uniform type of trend.

Conference with one leading expert and rental manager developed the fact that a given house schedule was worked out by men familiar with rentals and what could be obtained on the per room basis, and that this was then analyzed on the per square foot basis. This showed that the apartments in the north side of the house were evaluated at higher rates per square foot than the rooms in the south. This clearly indicated that the method of appraisal and evaluation was inconsistent and incorrect, since the reverse as based on desirability should have obtained.

Rentals vary with the floor level in the building and in general increase in elevator apartments as one gets above the noise, dirt, and heat of the street. Whenever setbacks occur in the building, affording terraces and

roof gardens for the tenant, this increases the rental rate, since the space outside the walls is not included in the number of rooms or the net rentable areas.

Graph No. 4 shows the results that were found in study of the same sized and oriented apartments floor by floor in given buildings. In one case the ground floor has a greater value due to the fact that it is possible to have a commercial use, and the size of the building and its population enhanced this possibility.

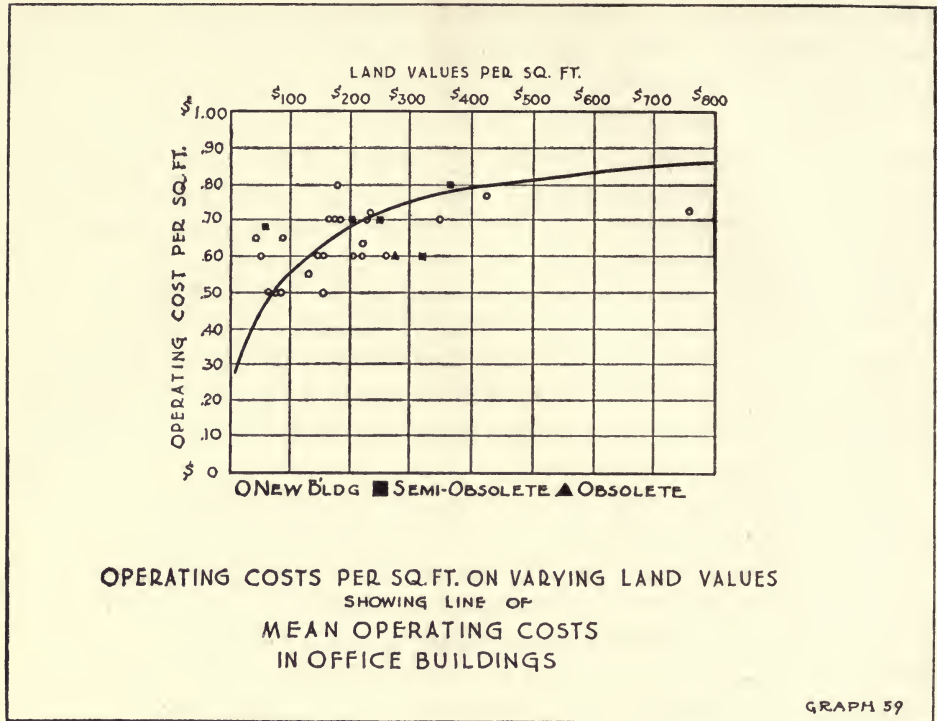
The majority of rental agents and apartment managers select the sixth floor as the standard and average in assigning rental values. The rentals on the lower floors are usually less than on the sixth, and the rental rates are generally progressively increased until either penthouse floors or floors with terraces and roof gardens occur, where the maximum rentals are found.

In working out the data for Graph No. 4, apartments of the same number of rooms and the same or equivalent orientation were used.

In addition to variation in rentals, the valuation of apartments recognizes such factors as frontage on streets, parks and open outlook, orientation to the points of the compass, and outlook on courts. In general, frontage on a street is a factor creating greater rental value, unless the street is very noisy, or unless superior conditions are provided by frontage on a large back-garden court. Other things being equal, the south exposure or orientation commands the greatest rental, while east versus west seems to be about equally divided, some tenants preferring one, some the other, and north outlook commands the lowest rents.

Such evaluations are most difficult to make, and are in general subject to many variations. The apartment-house rental expert can only arrive at a means and a method of evaluation on the basis of long experience and watching results in various buildings. If, for instance, he has set the rentals of different floors at different rent levels, and in one type, say, the upper floors are most rapidly rented, he can only assume that he has not assigned sufficient differentials for their rentals, and will do better later on renewals, or in some new and similar building. The same thing applies in the matter of assignment of differentials in rental for exposure, outlook, and orientation.

It was particularly interesting to note that agents confessed that their estimates were often upset in most unexpected manners by other conditions. For instance it was stated that in some houses where the address was considered exclusive and very desirable, they rented all the cheapest



apartments first after the late stock market crash. Tenants desired the "good address" and location and were not so much concerned by other factors.

In the estimation of rental roll in an apartment, it was found that in New York a vacancy factor of about 5 per cent and only occasionally 10 per cent was used. In other cities a larger amount and allowance is customary. It was usually estimated that the building, if the location was at all good, could be rented to the 90 per cent or 95 per cent occupancy within the year or less.

In estimating the loss from vacancy, there are two methods: either taking the full rent roll and using a factor of 90 per cent or 95 per cent as the net after-vacancy deductions, or by assigning the item of vacancy losses in the expense accounts. The former appears the more logical.

THE MAJOR FACTORS OF THE EXPENSE ACCOUNT

The main items of the expense account include operating, fire insurance, real estate taxes, depreciation or amortization, interest on the in-

debtednesses (including taxes paid at the source to state and federal governments) on mortgage bonds or their interest, and miscellaneous expenses.

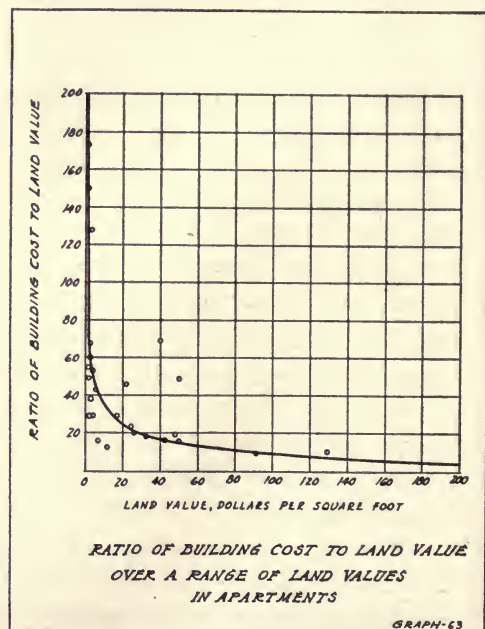
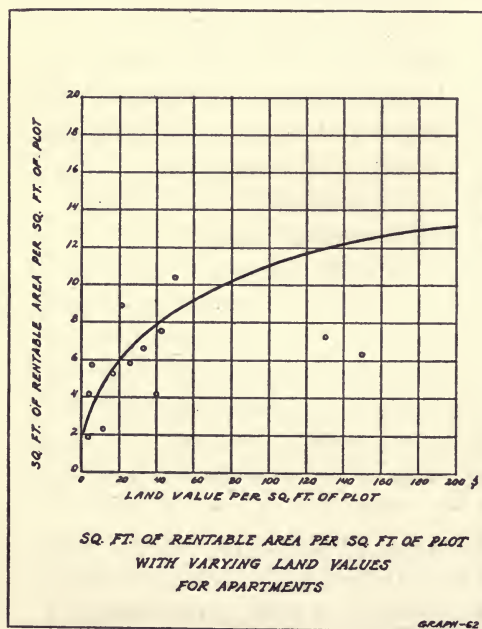
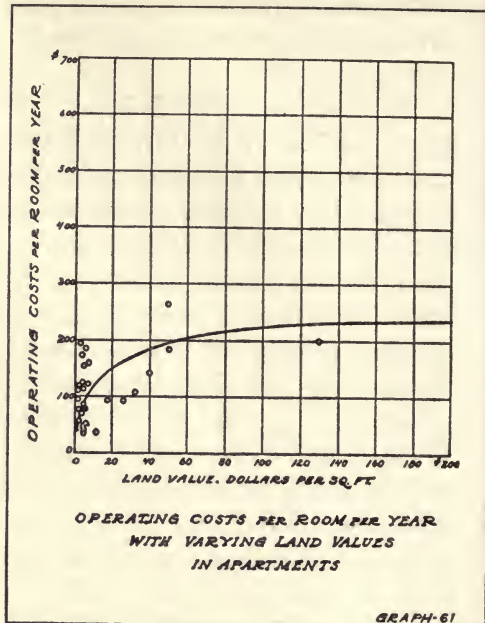
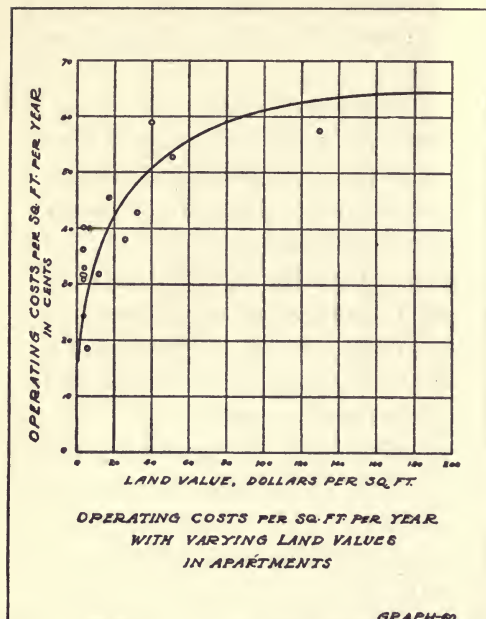
The real estate taxes depend on the community, its rates of assessment, and tax rates. In general in the absence of definite data, these may be taken as approximately the sum of the costs of building and land multiplied by a 75 per cent assessment factor and at a tax rate of about \$2.75 per hundred dollars of assessment. This results in a net tax of a little less than 2 per cent on the value or cost of the building and the land. Of course in an old structure the land may have enhanced in value and the building depreciated from its initial costs. This will have to be calculated as the circumstances direct, and it cannot be assumed that the enhancement of one will offset the depreciation of the other.

Operation costs include those of the office and management, the housekeeping (janitor service and cleaning, etc.), the engine room (heat, light, and power, and repairs in this department), elevators and their operation, the shops (carpenter, painting and papering, etc., either done with the building's own staff or contracted out in the case of small houses), and in general the costs of the various types of insurance, — fire, liability, and employees' liability (see Graphs Nos. 59, 60, and 61).

The costs of operation increase both as the types and classes of apartments increase in desirability and as the land values for the apartments increase. This is natural since the rental rates increase in this manner, and consequently the type and quality of service necessary and demanded increase. In all the above expense departments or items there are included wages, supplies, and miscellaneous. In the better type of houses the numbers of employees and their functions tend to increase.

On the cheapest land the majority of the apartments are of the walk-up type, and here there is no expense whatever for elevator service and power. In the better grade there are elevators, but of the automatic type without attendants, while in the highest grade of house there are not only attendants on the elevators, but doormen, porters, and the like. There are not only single shifts but reliefs and night shifts, etc., running up the costs not only in this but in the other departments of operation in a like manner.

The depreciation of the building or its amortization of indebtedness is usually figured on a percentage basis, and 2 per cent to 3 per cent is considered proper in the matter of depreciation. The amortization of the project is usually laid down in the mortgage terms, and its payments



thus reduce the indebtedness of the project and increase the owner's equity as the value of the improvement tends to waste away. The usual 2 per cent depreciation allowed by the Income Tax Bureau would imply, neglecting the influence of the creation of a sinking fund at compound interest, that the building would have a life of fifty years. This, however, would seem most improbable and it is a fortunate building that would last for even thirty years and still continue to be profitable and a good investment.

In general it would seem that a depreciation or amortization fund of about $2\frac{1}{2}$ per cent to 3 per cent should be set up in the accounts, and in many cases the terms of the mortgages would require that a larger sum than this should be designated to this purpose.

DEDUCTIONS AS TO THE REQUIRED SIZE OF THE BUILDING

Success in any building depends not only on the type and quality of the space provided, its relation to the demand of the market, and its rentals that can be obtained, but also on the size of the structure and its chances of earning an adequate return on the invested capital.

Much of the necessary data on which the design of the building should depend can only be deduced from a recent and up-to-date survey of the rental market in a given district and for a given type of apartment. There is so much involved in this that it cannot be adequately covered in this analysis. However, there are matters concerning the type and the quality of the space that it would be well to touch on before proceeding with discussion on the amount of space that is required.

In general, from discussion of the matter with the most successful operators, planners, and owners, it would appear that the present zoning laws allow the apartment owner ample bulk of building in the lower portions, and that many are finding it economic and profitable on certain large lots to build to a lesser coverage (with a smaller percentage of the area built upon) than the legal limit. It is not possible to say as much for the height limitations.

One point should be particularly stressed in the matter of coverage, and that is that the most economic building is not necessarily the one with the greatest coverage. It is frequently possible to construct on a smaller area, build less cubic foot volume, and attain a higher quality of space. The total income or revenue may be smaller, but with the fact that this is at a higher rate, coupled with the fact that a smaller building is constructed and the investment is smaller, this income may show a far

larger return on the investment and afford a greater degree of security to the building over a term of years in that it is less subject to losses of light, air, outlook, and privacy from the always possible construction of higher neighboring structures.

The quantity of space that is required adequately to develop the site is a matter of greatest importance and must be given consideration even on cheap land, while on valuable land it becomes a matter of paramount importance. This can only be arrived at by a series of estimates using different sized and arranged buildings, until one is found wherein the investment is held to the minimum consistent with the quality and the type of space that is to be created, and wherein the rate of return is the maximum.

Any individual case is thus more or less a law to itself, and in addition to the factors that have been enumerated above, it must be assured that the creation of a given amount of space in a given location of high land value will not exceed the market for space at the given time. If the market is clearly exceeded by the construction of the building of a size to afford an adequate return, it is obvious that some element of the problem has not been correctly evaluated, — in most cases the land, — but has been appraised at an unwarrantable and unsustainable value.

Consideration of the size of a building on the basis of the number of stories is all but meaningless since so many other elements enter into the matter. It would be likewise almost as indeterminate to discuss the number of rooms, unless the size of the plot, the coverage of the building, and many other factors are known.

Just as in the case of the warehouse, the loft, and the office building, the apartment-house owner has only one thing to sell, and that is the use of space of a given type and character, developed with given accessories and equipment. Space in terms of the net rentable area of a given type and character is a well-known and frequently used element in all kinds of rental, as is also the total area of the plot. In office and other kinds of buildings this rentable area per square foot of the plot is used as a gauge of the size or the capacity of the development, and it can be likewise used in the case of apartment houses.

If the amount of net area that is required per square foot of the plot can be approximately determined, then the designers of the building know what they must produce, and can proceed toward their solution of the problem, trying out various heights, percentages of the plot to be covered or built upon, and arrangements of suites and rooms. Their

problem should be to produce a given amount of usable space of the best possible quality and type within the ranges of the requirements of the improvement, and consistent with constructing the least possible volume of building.

Graph No. 62 shows the amounts of net area per square foot of plot that have been constructed by various planners, operators, managers, and owners in different cases. As previously stated these may in most cases be assumed to be too small rather than too large, since there is more of a tendency to under-build than to over-build. The value of the land in many of the buildings studied has enhanced above its value at the time of the erection of the building. In some cases, it is clearly the result of an unwillingness to throw what was deemed too much space on the rental market of a given district and section of the district, that has kept the size of the structure below the probable requirement of earning the maximum possible return on the project.

It is seen from this analysis that builders and owners have been led to construct as little as about two square feet of net area per square foot of plot on the land of lowest value, and from this up to as much as about eleven square feet of net area per square foot of plot on the most valuable land that was found in the apartment-house use.

Similar studies made of office buildings indicated that on land valued at from \$25 to \$50 per square foot (about the lowest values on which office buildings are customary) the development found was about eight square feet of net area per square foot of plot, and that the highest development found on the most expensive sites, costing \$500 per square foot and upward, was a little less than thirty square feet of net area per square foot of plot.

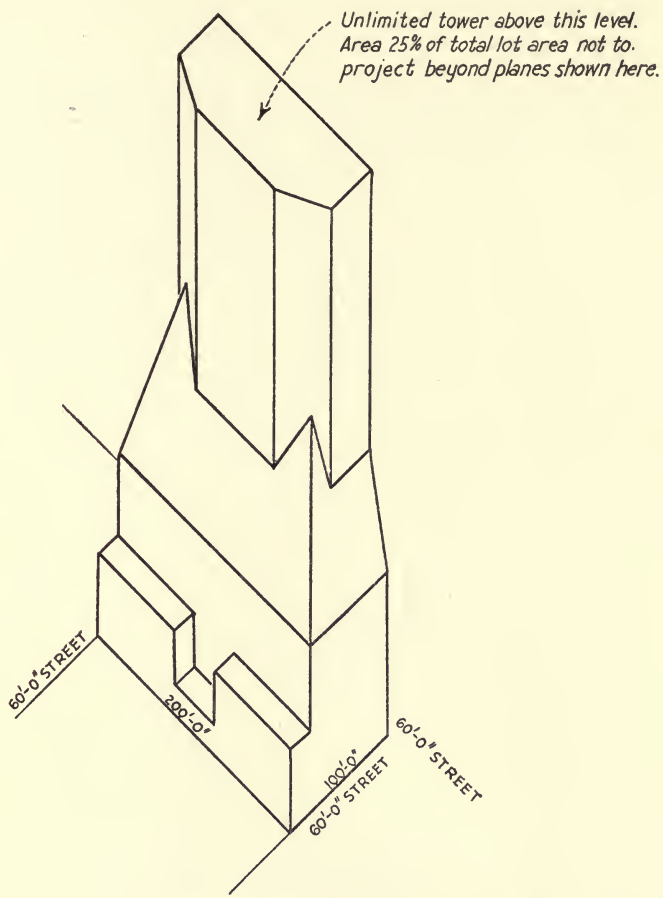
Thus the most intensive value of land is not found in apartment sites, and conversely it may be said that the apartment use of land is not as intensive or as high a use as is the office building, — that is, at the present time. What the future holds is very hard to predict, but it would not be unlikely that more and more valuable sites may be used for apartments, and these erected to greater and greater heights in order to justify the use of the land and afford a sufficient and adequate return on the investment. Just as American business has, by mass production, made possible to us all the use of the automobile and other luxuries, as they were considered, so another manifestation of this same principle — the multi-story building — may make possible the occupancy of intensively valuable sites as homes for the masses of the people. They may be

provided with convenient, centrally located apartments that will be just as desirable (and indeed infinitely more desirable from many stand-points) in skyscrapers as in low buildings.

The inherent virtue and general civic righteousness of the low building is often more apparent to some minds than real to others. That these low buildings cannot earn and pay an adequate return on high land values, unless developed as a mere temporary use and improvement or "tax-payer," is almost convincingly shown by the sky line of any American city, since it is a veritable vertical graph showing by its silhouette the ranges and the locations of high values and choice desirable sites.

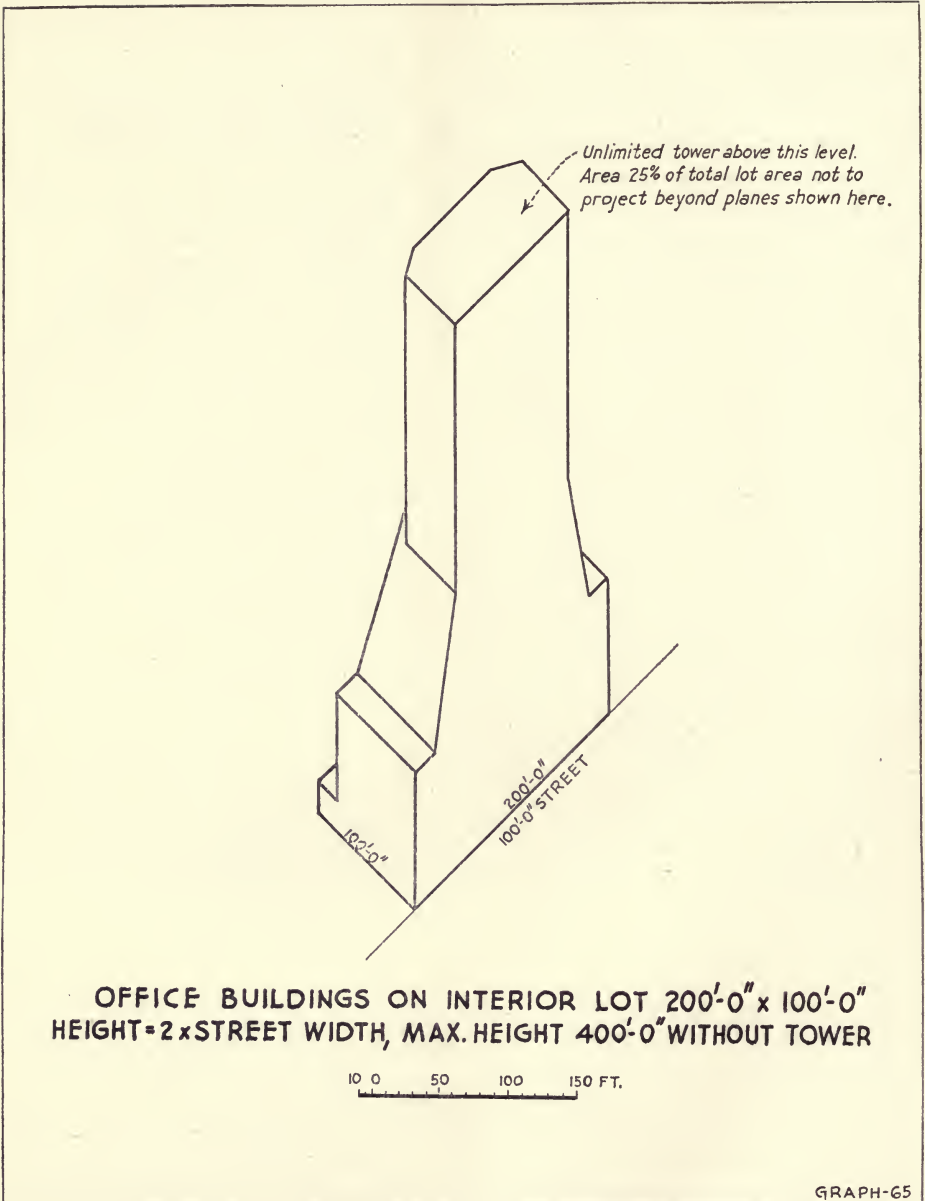
Graph No. 63 shows the ratio of the value or cost of the improvement (namely the building) related to the land value on various ranges of land values, as found from the buildings studied. It shows in a convincing manner that there is no rule of thumb for the construction of apartments, any more than there is such a rule for office buildings. In a given type of land and apartment house it may be very well to postulate that the building should cost, say, six times the land value, but this is a limited matter, and the slavish following of any such rule would lead to disaster on other plots and with other types of buildings.

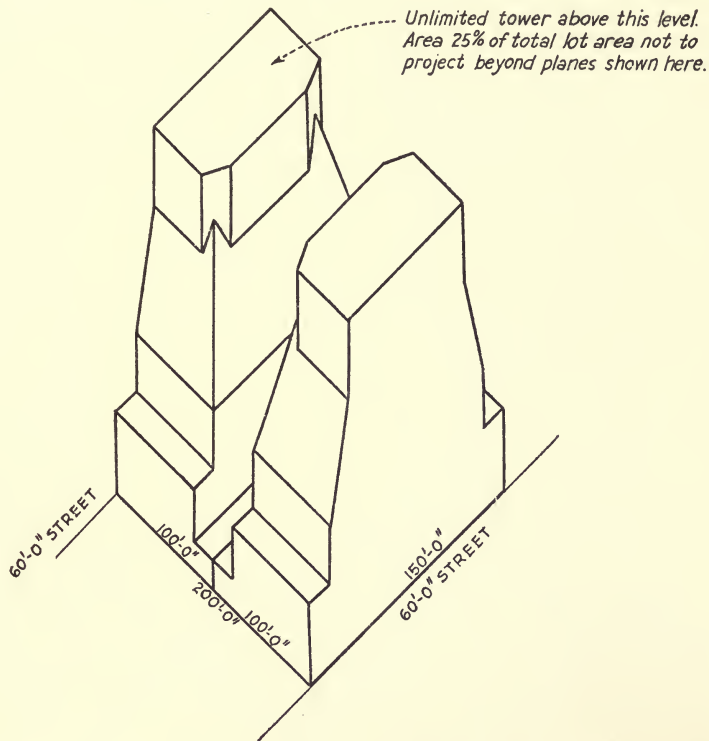
On the other hand any slavish devotion to the results here deduced would be equally bad, since some of the buildings studied and used as the basis for the indicated trend are, or may be, wrong and uneconomic. In fact, for the reasons given previously, they are probably likely to be too small rather than too large. At all events the factors analyzed should form an interesting point of départure in further work and study, based on the analysis of additional buildings, and with an attempt to work out what should be normally done on land of varying values.



OFFICE BUILDINGS ON CORNER LOT 200'-0" x 100'-0"
HEIGHT=2xSTREET WIDTH, MAX. HEIGHT 400'-0" WITHOUT TOWER



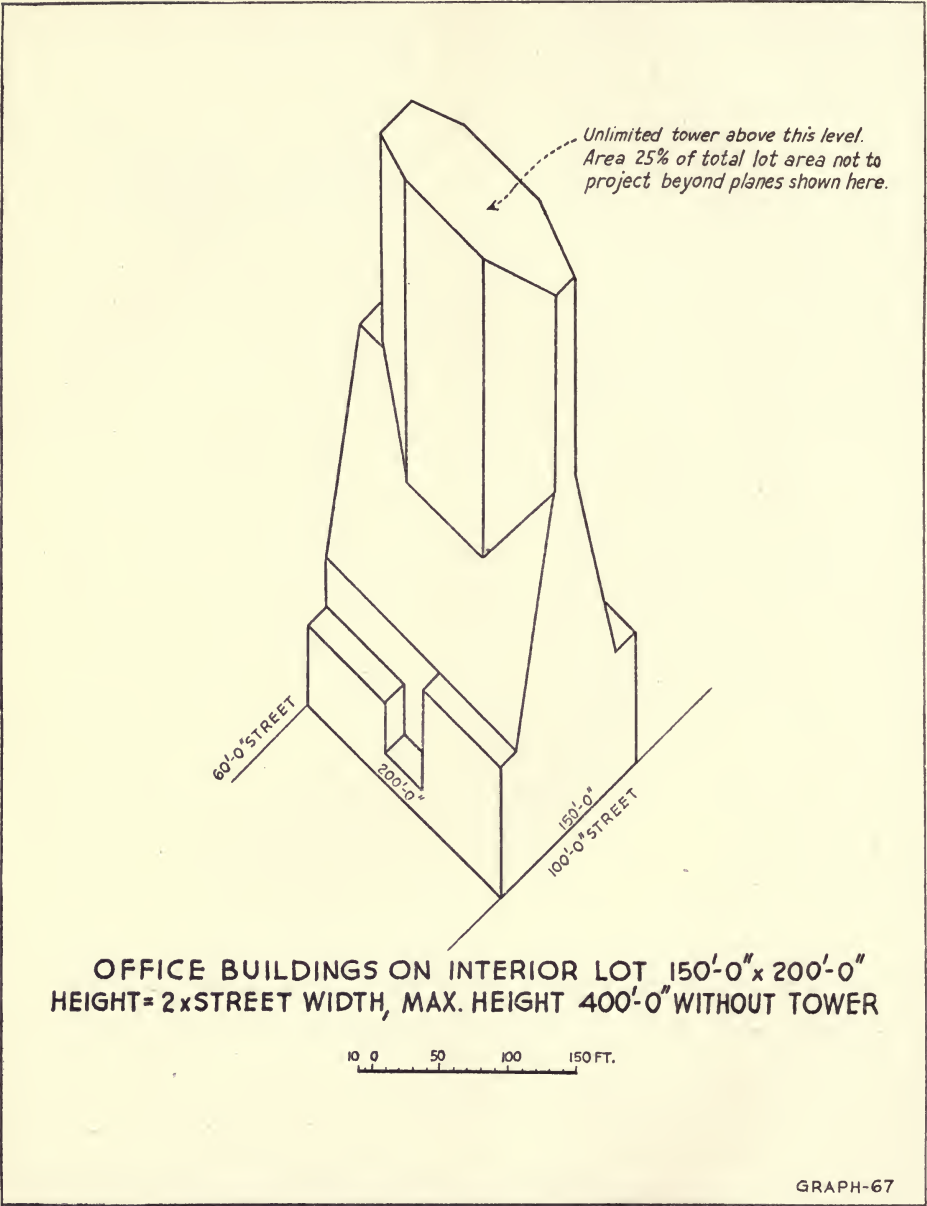


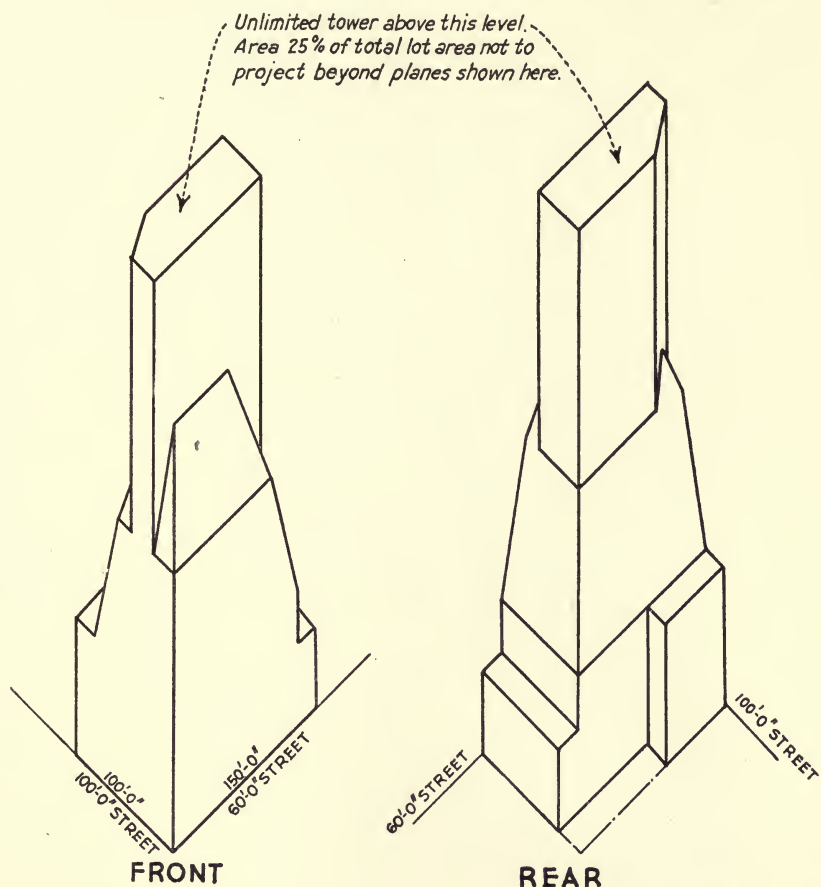


OFFICE BUILDINGS
FRONT & REAR ON INTERIOR LOT 100'-0" x 150'-0"
HEIGHT=2xSTREET WIDTH, MAX. HEIGHT 240'-0" WITHOUT TOWER



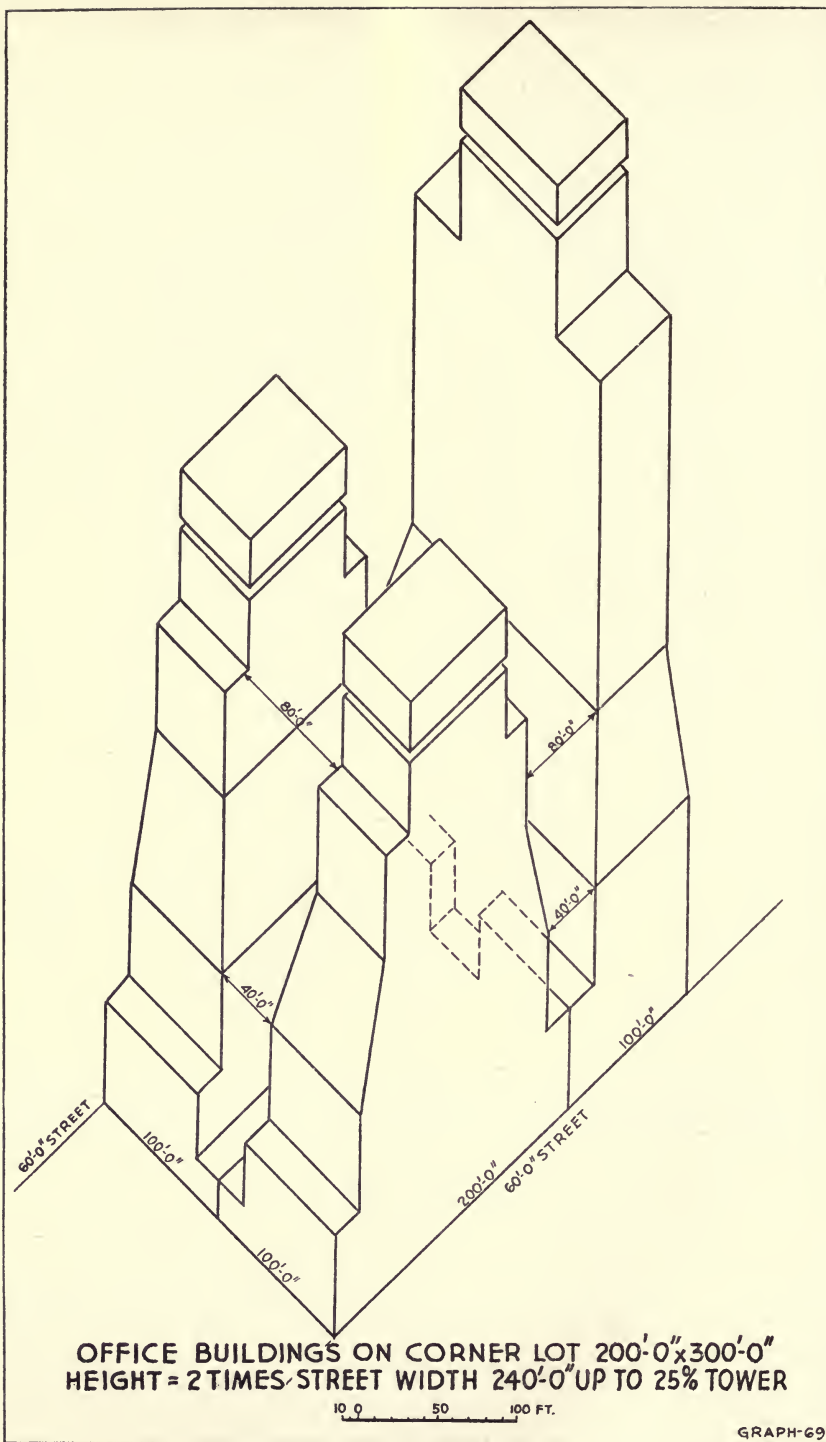
GRAPH-66

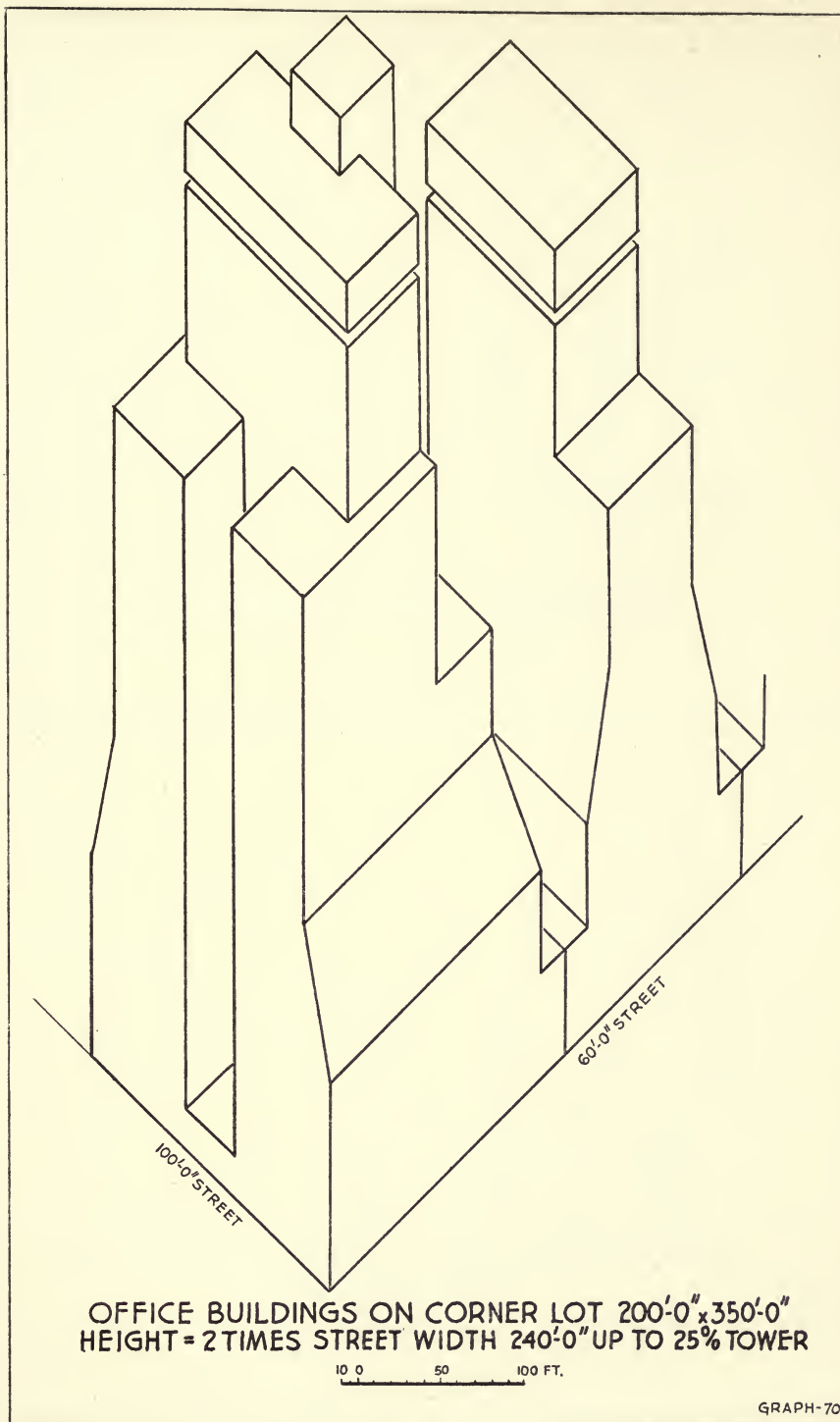


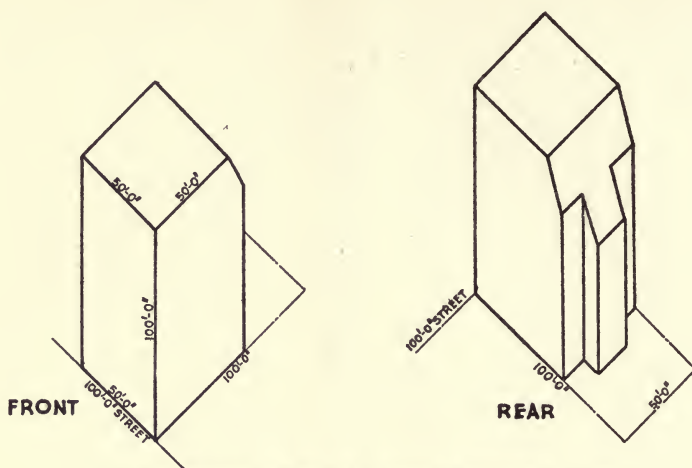


OFFICE BUILDINGS ON CORNER LOT 100'-0" x 150'-0"
HEIGHT=2x STREET WIDTH, MAX. HEIGHT 400'-0" WITHOUT TOWER

10 0 50 100 150 FT.

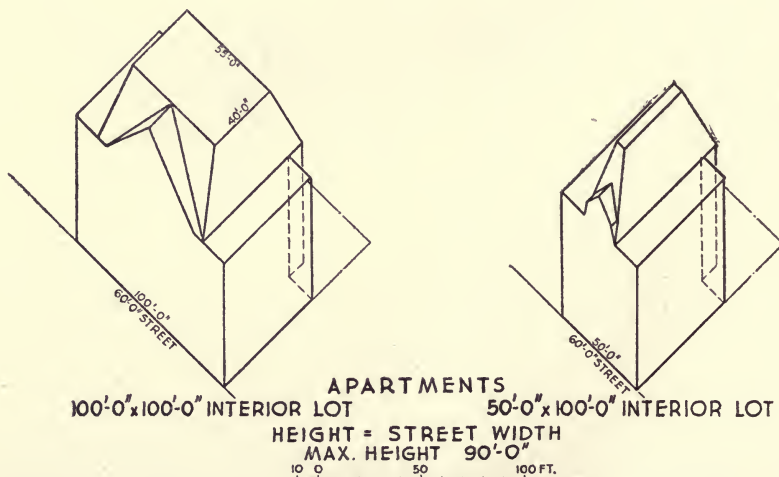






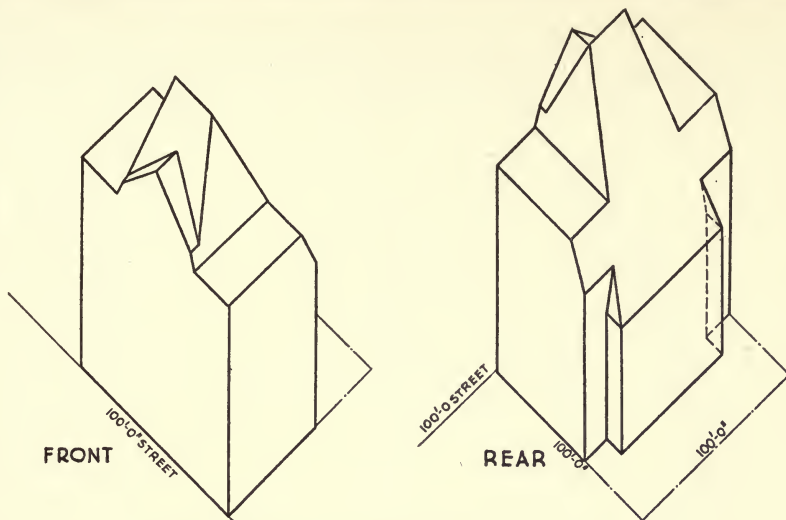
APARTMENTS ON 50'-0" x 100'-0" INTERIOR LOT
HEIGHT = STREET WIDTH, MAX. HEIGHT 150'-0"

GRAPH-71



APARTMENTS
100'-0" x 100'-0" INTERIOR LOT 50'-0" x 100'-0" INTERIOR LOT
HEIGHT = STREET WIDTH
MAX. HEIGHT 90'-0"

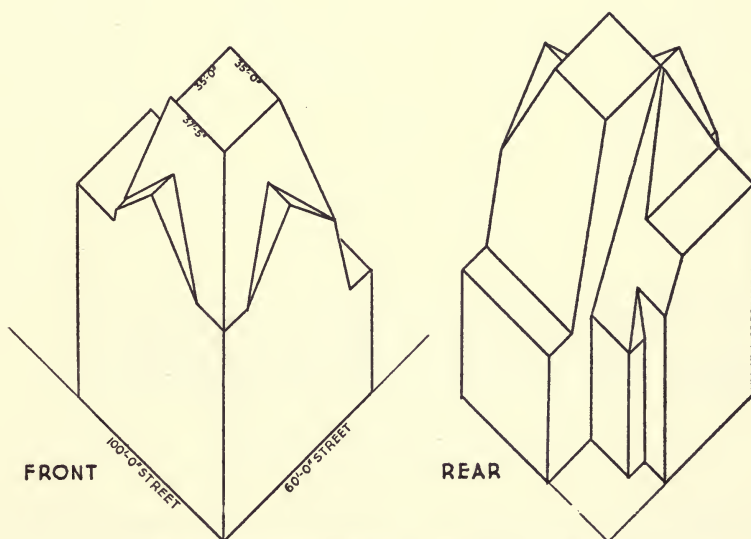
GRAPH-72



APARTMENTS ON 100'-0" x 100'-0" INTERIOR LOT
HEIGHT = STREET WIDTH, MAX. HEIGHT 150'-0"

10 0 50 100 FT.

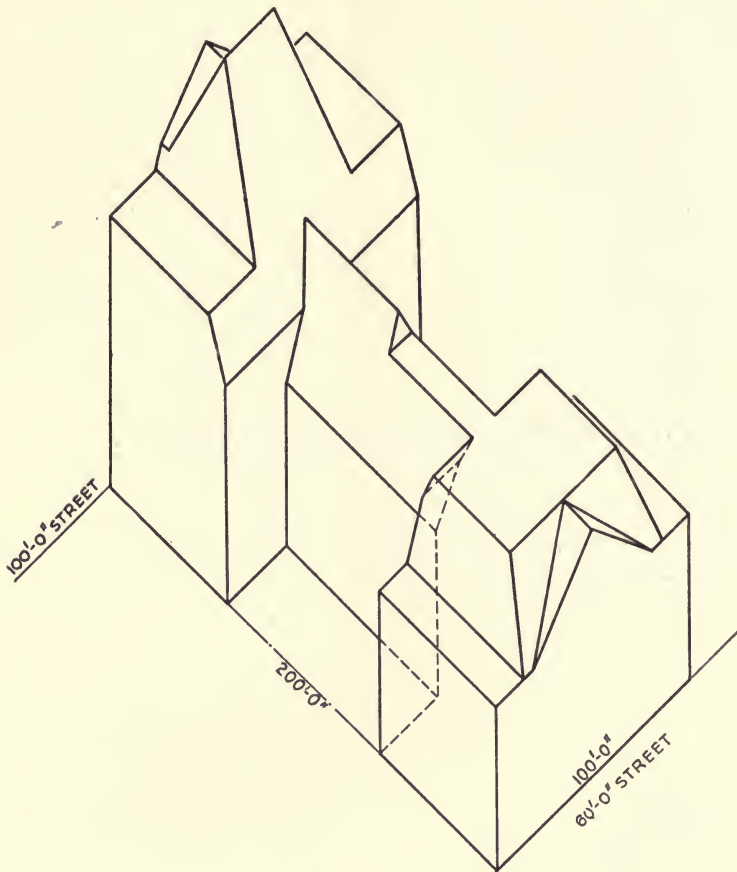
GRAPH-73



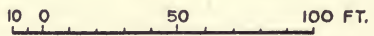
APARTMENTS ON 100'-0" x 100'-0" CORNER LOT
HEIGHT = STREET WIDTH, MAX. HEIGHT 150'-0"

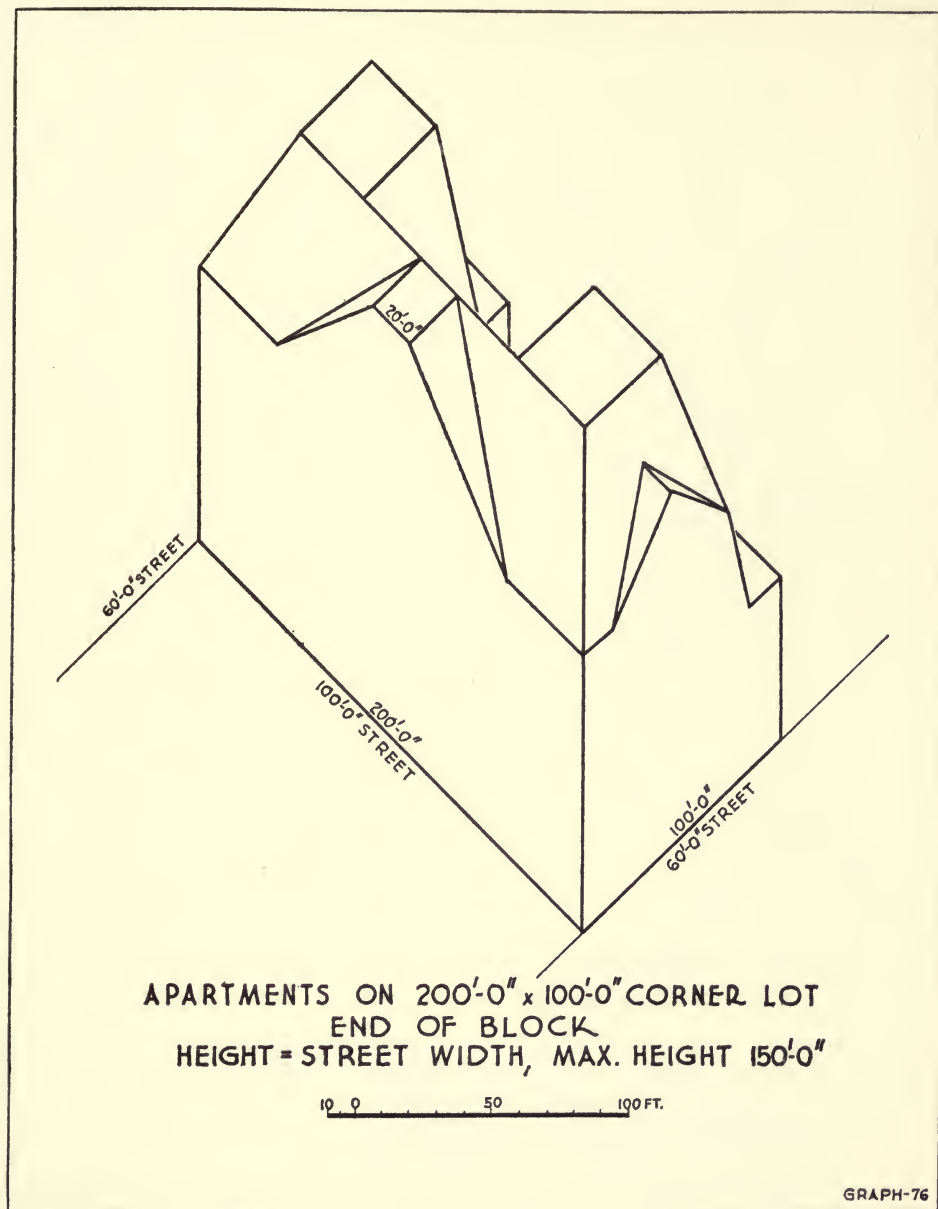
10 0 50 100 FT.

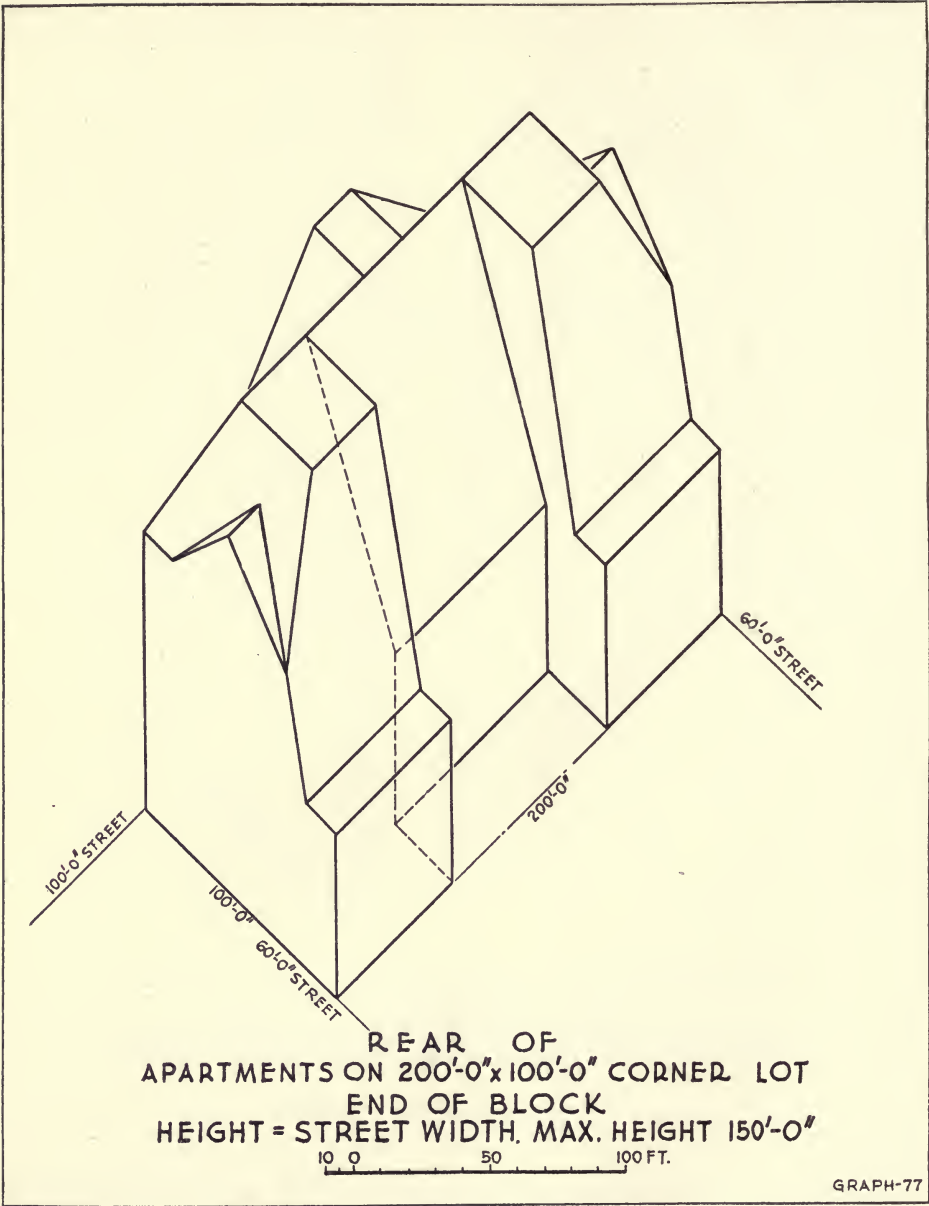
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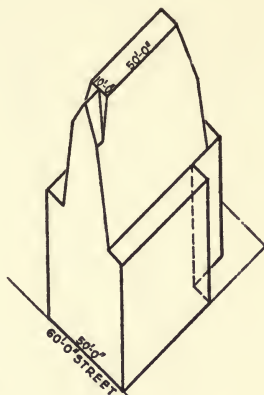
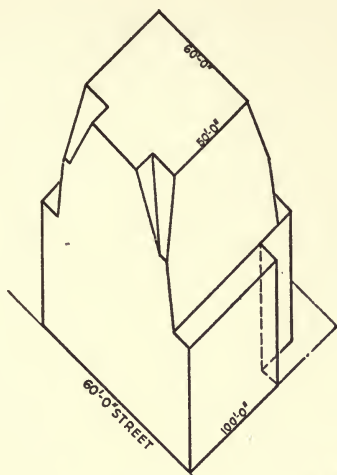


APARTMENTS ON 100'-0" x 200'-0" INTERIOR LOT
RUNNING FROM STREET TO STREET
HEIGHT= STREET WIDTH, MAX. HEIGHTS 90'-0" & 150'-0"





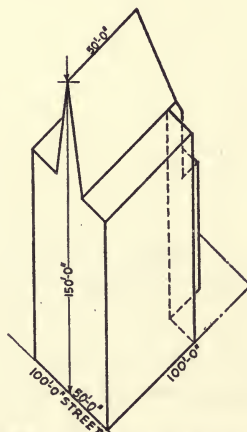
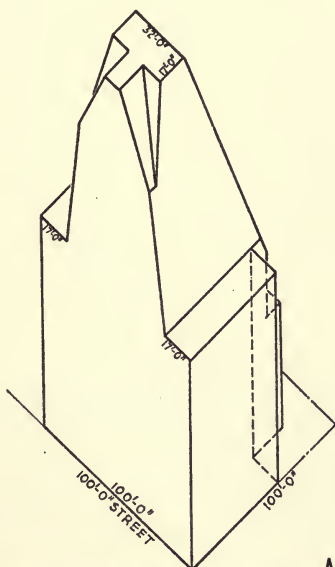




APARTMENTS
 100'-0" x 100'-0" INTERIOR LOT
 HEIGHT = $1\frac{1}{2}$ TIMES STREET WIDTH,
 50'-0" x 100'-0" INTERIOR LOT
 MAX. HEIGHT 120'-0"

10 0 50 100 FT.

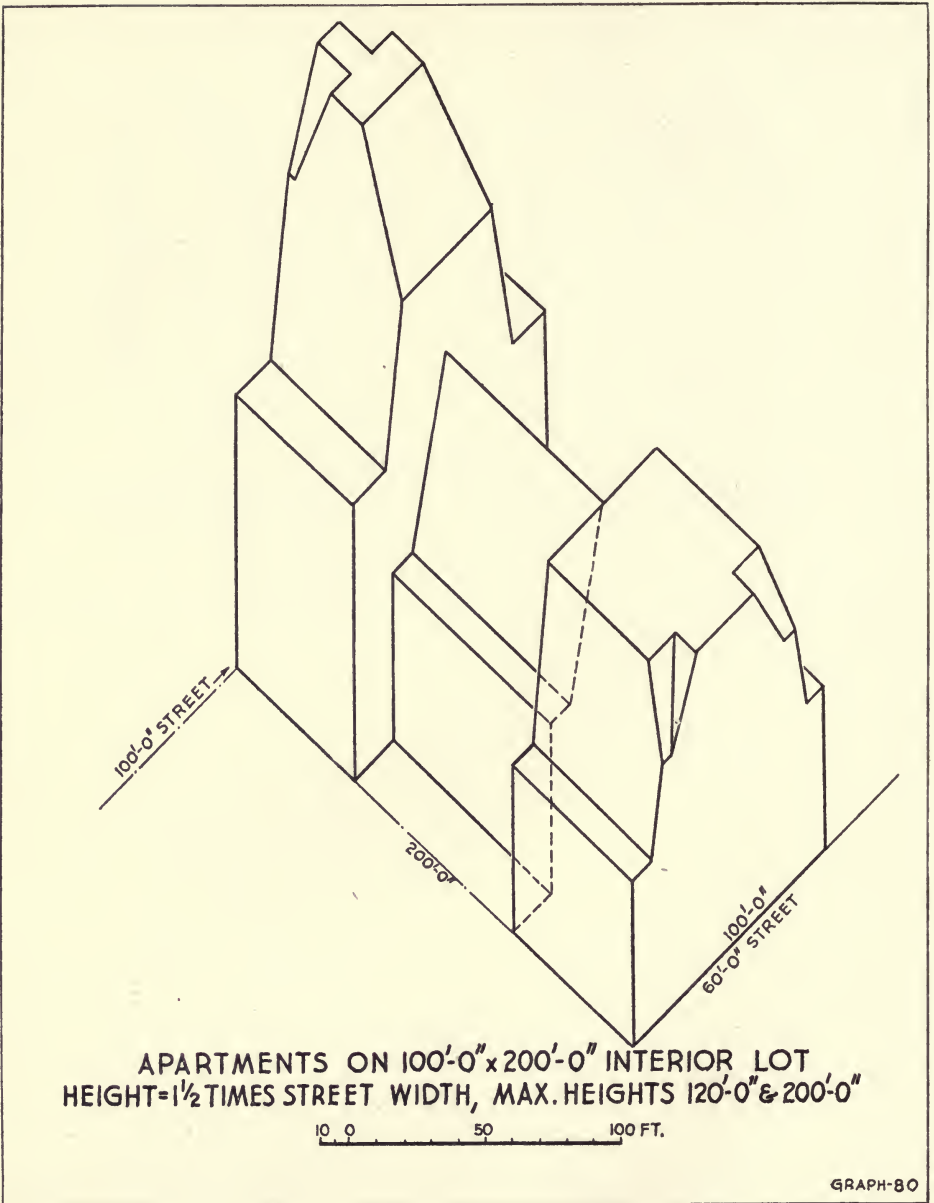
GRAPH-76

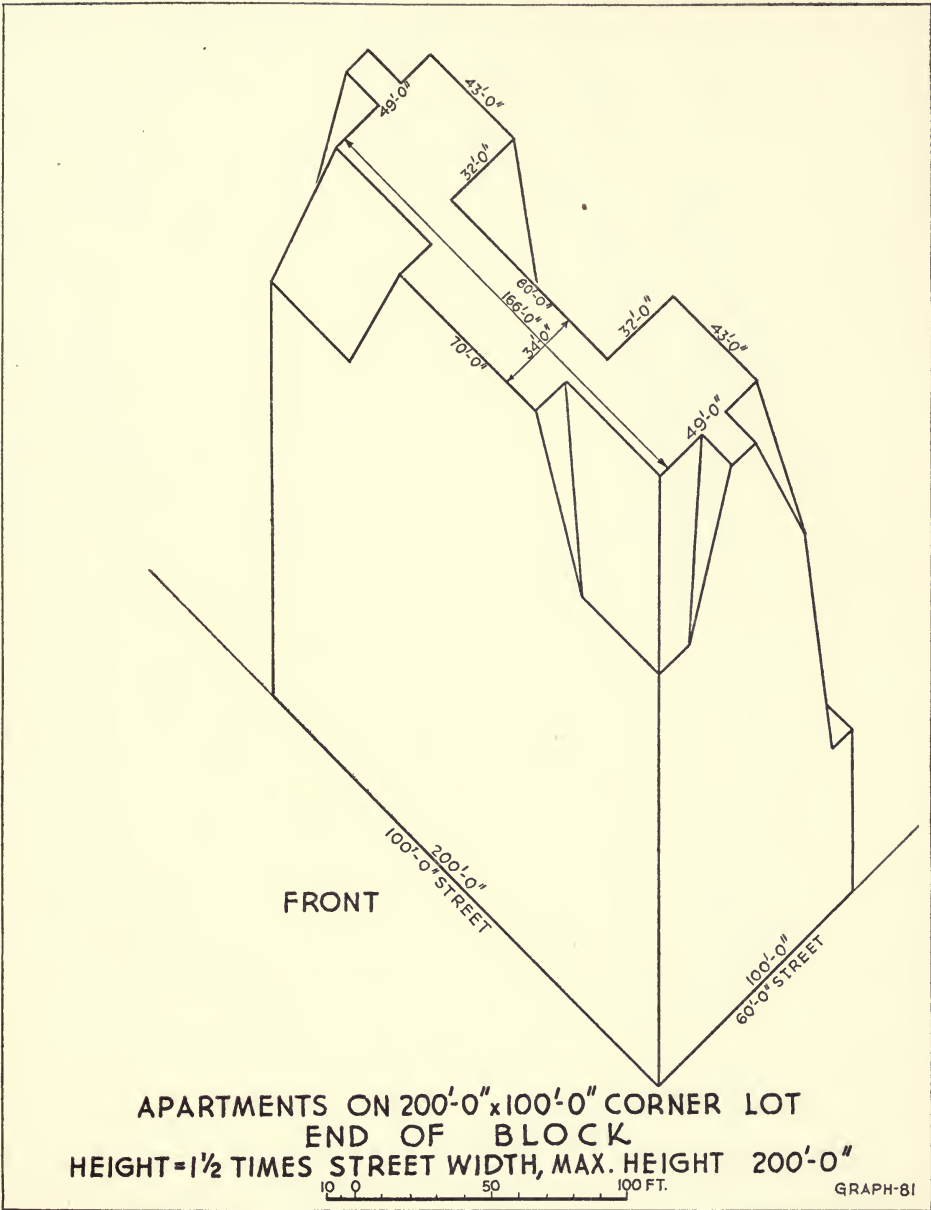


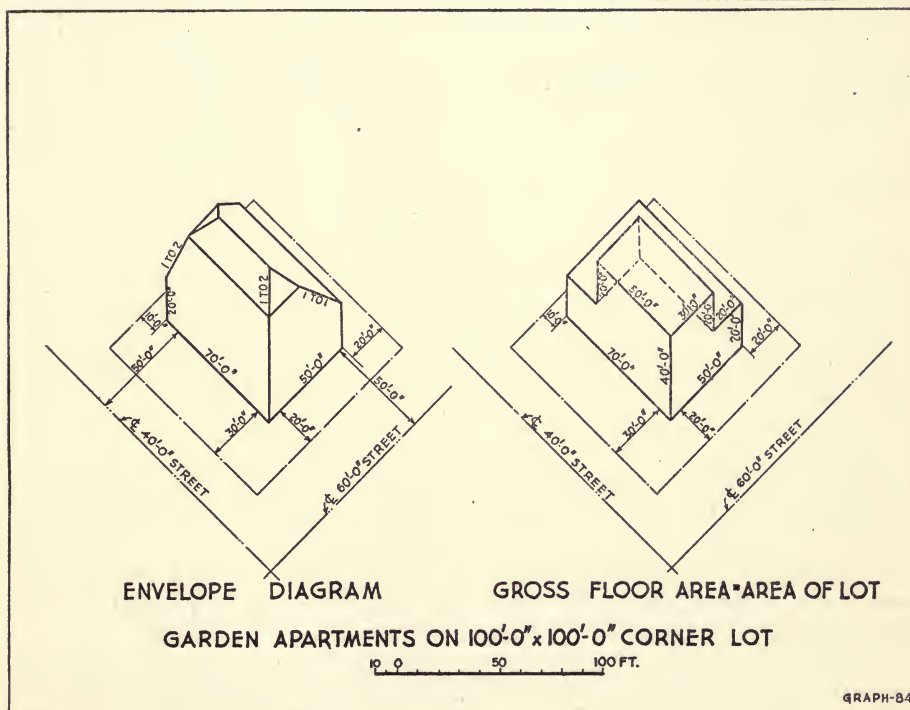
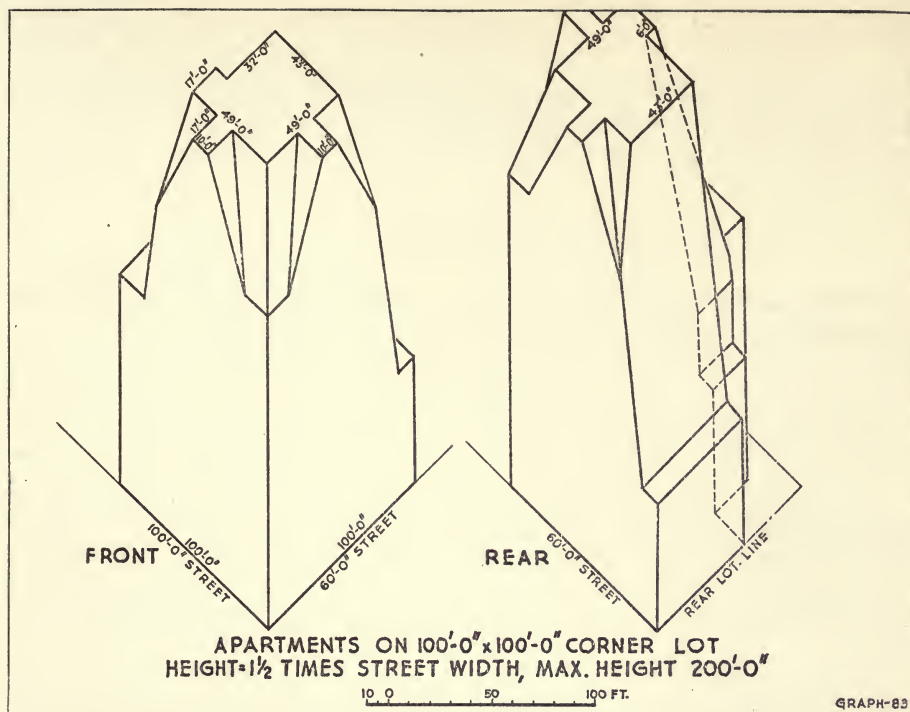
APARTMENTS
 100'-0" x 100'-0" INTERIOR LOT
 HEIGHT = $1\frac{1}{2}$ TIMES STREET WIDTH,
 50'-0" x 100'-0" INTERIOR LOT
 MAX. HEIGHT 200'-0"

10 0 50 100 FT.

GRAPH-75







NOTES

From article by W. R. M. Keast and A. B. Randall in *The Architectural Record*, April, 1930, explaining several graphs.

RENTALS

See Graphs 12 and 13, page 75, and Table VIII, page 93.

The income derived from office buildings is the rental (or rental value) of ground floor and other space. Rental value and land value are closely related. The same preference reflected in the land value has a resultant in rental value. It is easily understood that a land value of \$50 a square foot, on the edge of a district, could not command the same rental return for space in a building erected on it as could land worth \$300 per square foot.

While this differentiation is very apparent in ground floor rental values, it has also a great effect on the rental rates of the office floors. Ground floor rentals, on the basis of a large number of examples, seem to average their space value at a rate of approximately 6% on the land value per square foot. Since the area rentable on the ground floor is only about 70% of the plot area, the product of 70% times a rate per square foot of 6% of the ground value gives a very close approximation to the income that may be expected from this source. There are some theories according to which the ground floor rental will carry the land including interest and taxes; but even the best examples actually analyzed in this study did not give returns greater than those indicated above.

In addition to the relation of land value to office rental rates, there is another factor present in the relative quality of the building. It is obviously improper to put a first-class building on third-class land; conversely it is necessary to erect a first-class building on first-class land in order to obtain maximum rates. With the proper quality of building, therefore, the rental of offices on varying land values, and their relation to each other, have been plotted on [Graphs 12 and 13]. The curve shown is placed at the *maximum* rental probable in a building on a given site value, in order that the analysis may show the *minimum* size of building required.

Rental rates for offices are subject to variation based upon exposure and upon the height above the street. Rentals for spaces lighted by courts are often much lower than those on the outside; space on higher floors brings a markedly better rate than equal space on lower floors. Graph [56] indicates in a general way the variation of the average rental rate per floor for similar floors in a typical office building. The peak or rise of rate value at the center represents the floor where two express and local banks of elevators give accessibility from both the upper and the lower zones of the building.

Where there are undivided floor areas of abnormal depth, as in loft buildings and in certain of the lower zones of office buildings, the ratio of net area to gross areas is larger

than in first-class buildings. Rental rates should then be weighted. For instance, in a loft building of 85% net area to gross area, an office rate of \$2.48 per square foot would be equivalent to a rate of \$3.24 per square foot on a ratio of 65% net. Due weighting must be made in such areas for these factors.

EXAMPLES OF TRENDS IN LAND VALUES

See Graph 27 on page 136.

In a study of trends in land values over a period of time the official records of land assessments of the Times Square district in New York have been taken, and represent a fair maximum in established Eastern cities. A graph has been prepared showing the increase in land values in this district since 1904. It shows that some sites have increased slightly more than others, but that the average is in the neighborhood of 400%. A comparison with the 5% compound interest line will show a close correlation.

A comparison with the line of equivalent dollar *value*, however (number of dollars necessary to equal the same actual value) indicates that of this 400% increase, a large part is illusory.

Central Philadelphia valuations have not increased quite so much. Typical examples indicate a fairly close parallel to the New York district.

There may be other districts, both in Philadelphia and New York, where land has decreased in value. Sometimes the owners themselves do not realize this since the dollar yardstick by which we measure values is unstable and has changed so greatly in purchasing power. Due allowance must be made for it over a period of time. For instance, land that has apparently doubled in value over the last 25 years has actually only remained static in actual worth, since the dollar is worth only half what it was 25 years ago. Thus a property which has shown an increase of 50% in number of dollars is actually worth less than it was.

In the study of any particular property, therefore, it becomes necessary to obtain data on the historical trend of increase or decrease in value for the site.

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